SCEC

Southern California Earthquake Center

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Quarterly Newsletter
Spring 1996

Volume 2, Number 1

A Layman's Version of the *Phase II* Report: Probable Earthquakes, 1994-2024

The SCEC **Phase II** *report entitled* **Seismic Hazards in Southern California: Probable Earthquakes, 1994 to 2024** *is now one year old. For those subscribers who find the whole report overwhelming, we are preparing a two-part summary — Part 1, presented here, deals with the methodology of the report. Part 2, to appear in the next newsletter, will deal with the primary results.*

A Summary, Part I

Figures and tables referred to by number in the following text can be found in the original publication (*Bulletin of the Seismological Society of America*, Vol. 85, No. 2, pp. 379-439, April 1995); a reprint can be ordered through the SCEC Knowledge Transfer office, 213/740-1560 or *ScecInfo@usc.edu*.

The purpose of the *Phase II* report was twofold: a) to update estimates by the 1988 Working Group on California Earthquake Probabilities for large earthquakes on the San Andreas fault and its branches (Figure 5, page 404 of the BSSA publication), and b) to evaluate the

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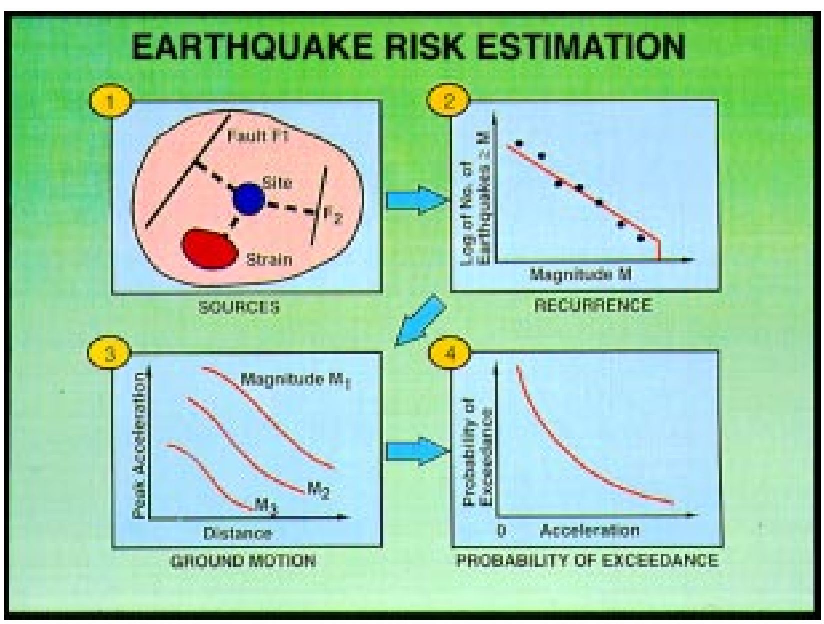
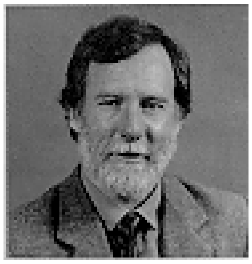


From the Center Directors...

Thomas Henyey
Center Director

David Jackson
Science Director



The Next Five Years: Goals and Objectives

*A*s most of our readers probably know, SCEC has begun the important process of preparing a proposal for the next five years of the Center's existence. The proposal is due for submission to the National Science Foundation in Washington, D.C., in June. If successful, the plans we make should carry us through our "sunset" in the year 2002. As part of that process, we recently met with our Advisory Council for feedback on our future plans. It is clear that the Council is still highly supportive of the Center, regarding us as a national resource and leader in earthquake research. However, the Council also had some constructive advice that we would like to share.

In our very first proposal, the "Master Model" took center stage, while the science was built around a set of eight working groups. At that time, the scientific issues relating to the Master Model and its improvement were not well developed, and the various working groups struggled to find their way. We believe a combination of the Center's scientific talent, with the occurrence of recent local earthquakes, produced some good results. The products are not only the release of the Phase I and Phase II Reports — and soon Phase III — but also the recognition of a series of critical issues that needed to be addressed in order to move seismic hazard analysis to a higher level.

The Council recognized this and advised us that returning to a "purely working group" format in the next five years would be a mistake. Instead, the next five years' efforts must be built around scientific objectives and concomitant research priorities. That is, budget development should emphasize the science, with the working groups supplying the necessary disciplinary input according to a set of research priorities. We agree with that assessment, and as such, will be organizing the first draft of the

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What Is the Southern California Earthquake Center?

*T*he Southern California Earthquake Center (SCEC) actively coordinates research on Los Angeles region earthquake hazards and focuses on applying earth sciences to earthquake hazard reduction. Founded in 1991, SCEC is a National Science Foundation (NSF) Science and Technology Center with administrative and program offices located at the University of Southern California. It is co-funded by the United States Geological Survey (USGS). The Education and Knowledge Transfer programs are co-funded by the Federal Emergency Management Agency (FEMA). The Center's primary objective is to develop a "Master Model" of earthquakes in southern California by integrating various earth science data through probabilistic seismic hazard analysis. The SCEC promotes earthquake hazard reduction by:

- Defining, through research, when and where future damaging earthquakes will occur in southern California;
- Calculating the expected ground motions; and,
- Communicating this information to the public.

To date, SCEC scientists have focused on the region's earthquake potential. Representing several disciplines in the earth sciences, these scientists are conducting separate but related research projects with results that can be pieced together to provide some answers to questions such as *where* the active faults are, *how often* they slip, and *what size* earthquakes they can be expected to produce. Future work will consider seismic wave path effects and local site conditions for developing a complete seismic hazard assessment of southern California.

More information: call 213/740-1560; e-mail: *ScecInfo@usc.edu*

Directors *continued from Page 2 ...*

proposal along the lines suggested by the Council.

Following discussions with the Council and the SCEC Steering Committee, and to begin dialogue among Center scientists, we have tentatively recognized four primary scientific objectives (for southern California) as follows:

• To improve our estimates earthquake time histories for a representative suite of plausible earthquakes;
• to improve our estimates of earthquake probabilities;
• to understand the extent of time dependence in the earthquake process; and
• to understand the importance and extent of stress transfer between faults and successive earthquakes.

While addressing these scientific objectives, we have further identified a set of research priorities or issues (not necessarily all-inclusive) as follows:

• To investigate and characterize the complexity of observed ground motions,
• to characterize the distribution of earthquake magnitudes,
• to explore clustering and other types of temporal variations,
• to look for evidence of stress interactions in the crust and upper mantle,
• to investigate the role of along-fault physical-property variations in earthquake magnitude distributions and the characteristic earthquake model,
• to understand the predictive value of earthquake dates and fault displacements,
• to understand the predictive value of historical seismicity,
• to understand the predictive value of geodetic strain rates, and
• to search for evidence of creep or great earthquakes as an explanation for the M=7 rate discrepancy.

These objectives and priorities give some idea of where we are as a scientific research center, and how we must think about the next five years. Each working group will have to decide how it can best contribute to the various research priorities (the matrix approach), and those with the best ideas will be the best-funded. Furthermore, it is perhaps less important that we focus solely on Los Angeles, looking instead at all of southern California, since the issues raised above tend to be generic, rather than site-specific, in nature. ♦

Thomas L. Henyey
and
David Jackson

Summary of National Science Foundation (NSF) Reauthorization Hearing

House Basic Research Subcommittee, March 22, 1996

Excerpts from a report prepared by Tim Clancy, NSF Office of Legislative and Public Affairs

The House Basic Research Subcommittee conducted a hearing on NSF's FY1997 Budget Request in preparation for the introduction of an NSF reauthorization bill for the second session of the 104th Congress. Last year the House passed an Omnibus Civilian Science Bill (H.R. 2405) containing a two year authorization of NSF programs, but the Senate did not take any action on the legislation.

NSF Director Neal Lane, accompanied by Deputy Director Anne Petersen, testified about the exciting opportunities in science and the importance of keeping America's investment in fundamental science strong for the future. "We are in a 'golden age' of science", Lane said, "where frequent breakthroughs are occurring in every field." Our nation's research and science education capacity is the "envy of the world" and this is in large part due to the federal investment in science and education, Lane testified.

Members generally voiced support for NSF and the important role it plays in supporting fundamental science and engineering. In his opening statement, Subcommittee Chairman Steven Schiff (R-NM) stated that NSF support of fundamental science was a critical investment for the nation's future. Noting the work of the Hayes Task Force on Supercomputing, Schiff praised NSF for taking steps to assist Congress in setting priorities in the face of tight federal budgets for science. He urged NSF to continue to do more to help Congress set priorities. Mr. Schiff also applauded recent statements made by Dr. Lane on the need for the scientists to take a more active role in informing Congress and the general public about their important work. ♦

Report *continued from Page 1 ...*

regional seismic hazard in southern California.

With regard to (b), our intent was to forecast, probabilistically, the earthquake hazard over the next 30 years. When we refer to "earthquake hazard" we mean the level of ground shaking, or more precisely the probability that the ground acceleration (usually for a specified frequency or range of frequencies) will exceed a given value over the 30-year time frame. In our Figure 18 (page 4 of this newsletter, and page 415, *BSSA* publication), we chose a peak acceleration of 0.2g (20% the acceleration of gravity) independent of frequency.

To compute the probabilistic seismic hazard throughout the region, we need to know (refer to the figure on page 1): a) all of the earthquake sources in the region (top two panels in the figure), b) how the seismic waves are affected as they propagate from each source to each site, and c) the elastic-wave properties of all of the sites in the region . In order to simplify the problem, seismologists and engineers usually lump (b) and (c) together into what are called “attenuation relations” (lower left-hand panel in the figure), and limit the number of site conditions to a few generic ones.

We made the simplifying assumption that all sites consisted of “hard rock” and used an average attenuation relation reflecting that assumption. We took this approach because in this version of the “Master Model,” we primarily focused on the earthquake sources. We characterized the active faults on a regional basis, and reached consensus on the important parameters for each fault (Table 1, page 383, *BSSA* publication) — i.e., the recurrence interval, slip rate, maximum earthquake, and date of the last event.

Later versions of the Master Model (currently in preparation) will specifically address the *path* and *site* conditions.

Because there are a large number of possible earthquake sources, known and unknown, in southern California, we followed standard procedures used in probabilistic seismic hazard analysis and divided southern California into seismic source zones (Figure 6, page 405, *BSSA* publication). Many of the 65 source zones coincide with active faults whose parameters are reasonably well known. Other zones are essentially seismotectonic provinces characterized by a common structural style. It was then necessary to assign a *seismic moment rate* to each source zone — i.e., the rate at which seismic or strain energy is liberated in each zone. Seismic moment rate is proportional to rupture area, multiplied by average slip rate. The sum of all 65 seismic moment rates

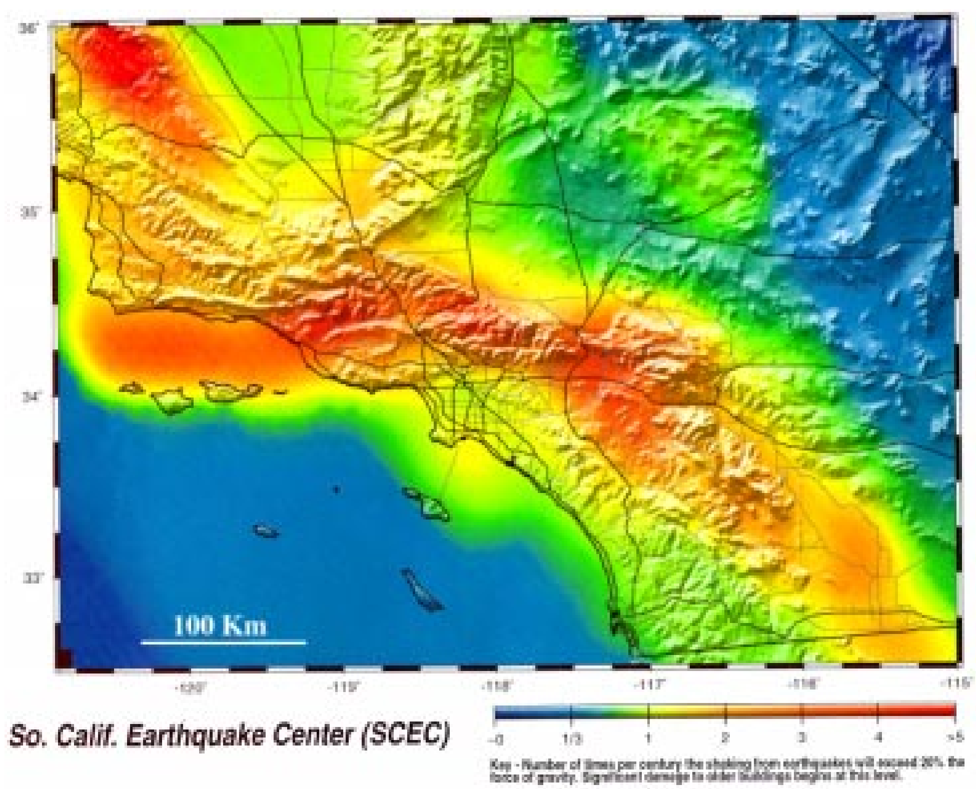

Figure 18.

Report *continued from Page 4 ...*

should not be appreciably different from the long-term moment rate contributed by plate tectonics.

Paleoseismic, historical seismicity, and geodetically-determined strain rates were used to estimate seismic moment rates in the 65 source zones. Three types of source zones — A, B, and C — were recognized.

Type A zones contain faults for which paleoseismic data are sufficient to estimate seismic moment rate and conditional probabilities. Type B zones contain faults with insufficient paleoseismic data, and Type C zones contain diverse or hidden faults.

First we summarized the most recent paleoseismic and geologic data (slip rates, characteristic displacements, recurrence intervals, date of last characteristic earthquakes and lengths of segments) on the major faults in southern California. We also updated the 1988 Working Groups' estimates of the conditional probabilities of earthquake occurrences on various fault segments (Type A zones) over the next 30 years (Table 2, page 386, *BSSA* publication). We assumed a modified characteristic earthquake model in which slip is dominated by earthquakes that rupture an entire segment, but allowing for the simultaneous rupture of contiguous segments (the so-called "cascade" model). Cascade rates were chosen to correspond as closely as possible with rates of observed multiple segment ruptures such as the 1690 and 1857 earthquakes on the San Andreas fault.

Probabilities for segment-rupturing earthquakes in the coming 30 years on the major faults were calculated with three different time-dependent models and are presented in Table 2. Also shown in Table 2 is a weighted average from the three models. For comparison, the time-independent Poissonian and 1988 Working Group probabilities are also shown. The changes in the probabilities since 1988 are largely a result of the improved geologic database.

Next we developed probabilistic estimates of earthquakes and strong ground motions for all of southern California based on the total of all potential earthquake sources (Figure 18). This involved first extending our moment rate estimates to the Type B and Type C zones and then calculating the regional probabilities. In addition to the moment rates, the calculations require estimates of the earthquake magnitude-frequency distribution and maximum magnitudes in each seismic zone. Maximum magnitudes were based on consensus geologic estimates of fault or segment lengths and applying the regression formula of Wells and Coppersmith. A modified Gutenberg-Richter magnitude-frequency distribution (decreasing more rapidly for larger magnitudes) with allowance for extra characteristic earthquakes also was assumed.

Unlike the Type A zones, which contain sufficient paleoseismic and geologic data for moment rate estimates, rates for the Type B and Type C zones were determined by other means. This included a) "best guess" consensus geologic estimates, b) the historical (since 1850) earthquake record, and c) geodetically-determined strain rates. In the case of the historical record, it was assumed that future earthquakes are most likely to occur in those regions where earthquakes have occurred over the last 150 years. For geodetic strain rates, it was assumed that high strain rates imply high earthquake potential. The so-called "Kostrov equation" was used to convert strain rate to moment rate.

For Type B zones with documented faults but lacking good quality slip and recurrence data, the moment rate was taken as the mean of the best-guess geologic estimate and the geodetically-determined rate.

For the Type C zones with poorly exposed faults or little geologic control, the moment rate was determined from the mean of the rates determined from geodesy and the historical seismicity. The key data for all 65 source zones are summarized in Table 5, page 396, *BSSA* publication. Because we have variously combined the geologic, geodetic, and historical seismicity data to determine moment rate, and have made assumptions regarding maximum magnitude, frequency-magnitude distribution, etc., Table 5 is really a combination of data and model — our *preferred* model.

An alternate model is shown in Table 6, page 397, *BSSA* publication, where the maximum magnitude estimates in all source zones have been increased by one-half magnitude or to M=7, whichever is greater. This has the effect of putting more moment into larger earthquakes, thereby reducing the number of intermediate and smaller events required to release an equivalent moment. This would mean bigger but more infrequent earthquakes and a *reduced* earthquake hazard. As an example, an M=7.5 earthquake has the equivalent moment of six M=7 events or 32 M=6.5 events.

Finally, the models in Tables 5 and 6 can be used to calculate regional seismic hazard. The general methodology for this is well established in the literature. We used the line source model for the high-angle faults in Type A zones, while for Type B and Type C zones, the standard procedure was modified in such a way as to accommodate geologic constraints implied by the shape of each source zone as well as take into account the differences in focal mechanisms and fault dip. ♦

Selected SCEC Research Abstracts
...What Are We Studying?

The SCEC Annual Meeting, held in Septemer, 1995, featured presentations and posters with highlights of SCEC-sponsored research projects. We've added this new department as a way of alerting our readers to topics of focused research.

Scenarios of Time-history Generation and Effects of Local Site Characteristic on Ground Acceleration

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Department of Earth Sciences, University of Southern California, Los Angeles, CA 90089

Geoffrey R. Martin
Department of Civil Engineering, University of Southern California
Los Angeles, CA 90089

The objective of this study is to present results of time histories modeling of earthquake scenarios in the Los Angeles Basin. The ground motion records calculated by a time-history working group were first validated with the records from the 1992 Landers earthquake and the 1994 Northridge earthquake.

Quantitative comparisons were made for both time duration and response spectral values. The bias calculated from all groups is smaller than a factor of two. Five earthquake scenarios (M7.9 on the San Andreas, M6.75 and M7.25 on the Palos Verdes fault, M6.75 and M7.25 on the Elysian Park fault) were selected and two CDMG station sites were chosen for this study. The sites are the Rolling Hills Estate (denoted as RHE, CDMG#14405) and Temple and Hope (denoted as TAH, CDMG#24611). We tested these physical modeling results against empirical attenuation relations.

For a magnitude 7.25 scenario earthquake on the Palos Verdes fault, for the near fault zone site RHE, the empirical models show lower predictions by a factor of two compared to physical predictions. In the other hand, for the site TAH, both empirical and physical models match well for the whole frequency range. Non-linear one dimensional site response analysis has also been used to modify selected time histories to reflect representative site soil conditions.

Strong-Motion Site-specific Amplification Factors for Southern California

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We updated the existing SCEC/ICS strong-motion database to include response spectral ordinates and site-specific amplification factors for sites recording events since the 1933 Long Beach earthquake up to and including the 1994 Northridge quake. Response spectral acceleration, velocity, and displacements were first calculated for each event at each site in the database.

The attenuation relation of Sadigh et al. (1994) was used as a reference model for a site-specific comparison of the site's peak ground acceleration and specific response spectral values. Strong-motion data is compared with this attenuation relationship in order to find site amplification or de-amplification factors. We also calculated amplification factors using the average rock response spectral values as a reference.

The results of these comparisons will be available through the strong motion database. The records will consist of four amplification factors at each site for all available events within the southern California region. The four amplification factors are at periods of 0.1, 0.3, 1.0, and 3.0 seconds. The sites were chosen because of their structure type and geographical position. Sites were limited to include only those located in the southern California region (with a maximum latitude of 36.0 and a minimum latitude of 32.0) and those that could be classified as free field. These results will help to produce a more complete understanding of seismic hazards for the southern California and assist in the further study of seismic events.

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Quarter Fault

Each Issue of the SCEC Newsletter features a southern California fault. In this issue...

The Whittier Fault

(Plus A Look Back At The 1987 Whittier Narrows Earthquake)

Clockwise, from right: 1) The Olinda oil field, 1992. Meticulous Tom Rockwell's hand-excavated trenches along the Whittier fault. Six channels were traced across the fault. Maria Herzberg and SCEC intern Kim Thorup learned that a two week job, well done, can take seven months to complete. 2) Whittier Narrows, October 1, 1987. One trashed house, one couple happy to be alive. 3) A stream channel offset to the right by the Whittier fault in the Olinda oil field area. The fault is located roughly one third of the way down from the top of the picture— note the notch on the offset ridge to the left.

As little as ten years ago, relatively few people actually worried that a major earthquake might occur within the greater Los Angeles Basin any time soon, despite the M_L 6.7 Sylmar earthquake in 1971. The Sylmar quake, though widely felt, didn't produce too much damage in L.A. and so it was easy enough to forget (the way we all forget virtually everything anyway), especially at the beginning of the 70s—what with America's withdrawal from Vietnam, Watergate, disco dancing, and other diversions grabbing our attention. The possibility of a large quake on the Newport-Inglewood concerned a few geologists, but for most part, the image of a major earthquake toppling sky-rises or devastating vast tracts of the city seemed more like science fiction than reality—something you'd only see in a movie.

But the 7:42 a.m. October 1, 1987 Whittier Narrows earthquake changed all that. It was nature rolling L.A. out of bed, with a wake-up call, suggesting that the distant San Andreas might not be the most dangerous fault around; and just as importantly it demonstrated blind thrust faults can wreak major damage within the basin. For although scientists had begun to start thinking quite seriously about blind thrusts after the 1983 Coalinga quake (M_w 6.5), no one had really thought about the idea that there might be some dangerous ones underlying Los Angeles.

With the Whittier Narrows earthquake, Angelinos could also, for the first time, see what green and tidy utopian Beaver-Cleaver neighborhoods can look like after some heavy shaking. The M_L 5.9 main shock originated at a depth of 14 km's near the intersection of Rosemead Boulevard and Garvey avenue in Whittier. The earthquake caused some $300 million damage in L.A. and Orange counties, including damage to 10,500 structures, and it knocked out power to 500,000 customers. Horizontal peak accelerations reached up to 0.6 g's (the force of gravity) at one station, located 50 km's from

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Whittier Fault *continued from Page 7 ...*

the epicenter. All told, some 100 fires broke out throughout greater Los Angeles. Power to more than 500,000 customers was disrupted. Telephone service was out in wide parts of the city. Miraculously only three people died.

Yet bad as this earthquake was, it didn't occur on the Whittier fault proper, which is where seismologists initially thought the event had originated and it was really just a small-scale taste of what will eventually happen on the Whittier fault when it eventually produces a 7+ earthquake.

The Whittier fault is a 40 km long segment of the Elsinore fault zone which lies between the Santa Ana and San Gabriel rivers. It has a slip rate of roughly 3 mm/yr. The fault is almost exclusively right lateral, is expected to slip three to four meters in a large earthquake and according to trenching done by Tom Rockwell and Eldon Gath probably has a recurrence interval of 1500 to 2000 years. The last 7+ earthquake on the fault appears to have happened roughly 1400 to 2200 years ago, so it could be ready to rupture again.

Economically, the Whittier fault zone is also important, in that it probably is the L.A. basin's biggest oil trapping structure, after the Wilmington anticline, and the Newport Inglewood Fault zone.

The Whittier fault can be seen in a number of areas, including Yorba Linda and the Olinda oil fields where streams crossing the fault are offset horizontally to the right by movement on the fault. Possibly the best way to appreciate the power and potential of it, however—given that it's been graded and concretized to near invisibility under our ever growing urban sprawl—is to spend a Friday night with a friend in an old muscle car with a turbo-charged V-8 engine and a good sound system and go for a ride in the many hills at the north end of the fault. The Puente, Coyote, Montebello, Chino, Kramer, Olive, Peralta, and Whittier hills, are either wholly or partially the result of strain from the 5 mm slip on the Whittier-Elsinore fault system being fed into the L.A. basin. When the slip in the crystalline terrain of the Peninsular ranges batholith hits the sediments of the greater Los Angeles basin, massive folding occurs. The curves and stomach-dropping dips along some of the back roads in the hills are much more of an impressive and unsettling expression of the power of the Whittier fault than its offset streams.

With parts of the hills still sitting undeveloped, you can find lampless, dark stretches where your headlights will hit only the white eyes of coyotes, skunk and possums and you can momentarily forget you are in a 20th century megalopolis—that's until you roll over the next hill-crest, where you see L.A.'s tens of millions of lights sparkling brightly below you again.

It's always a little unnerving to realize that an earthquake could pull the plug on much of that vast and comforting blanket of electric snow at any time. ♦

Michael R. Forrest

1996 SCEC-Sponsored Field Trip Postponed

Save the Date!

Friday, July 19, 1996
The Whittier-Northern Elsinore and Newport-Inglewood Fault Zones
with Dr. Thomas Rockwell, Dr. Lisa Grant, and Mr. Eldon Gath

Three leading experts on late Quaternary fault activity in Southern California Faults, will conduct a Whittier-Northern Elsinore and Newport-Inglewood Fault Zones Field Trip on Friday, July 19, 1996.

These faults are two of the most hazardous in the Los Angeles region, due to location. The trip will feature a review of sobering but utterly fascinating, recently-unearthed data. In addition to presenting the latest information on the faults, leaders will discuss the science of paleoseismology and recent trenching in these fault zones. Meals and transportation will be provided for attendees. A splendid, though unsettling time, is guaranteed.

NOTE: The field trip is designed for corporate representatives, public policymakers and professionals concerned with effects of urban earthquakes. The purpose is to raise funds for the first in a series of SCEC field guides to southern California Faults. Participants will receive a free guide and t-shirt. Cost per seat ($169) includes continental breakfast and lunch. There will be no media coverage.

Contact the SCEC Knowledge Transfer Office, phone 213/740-1560 or e-mail *ScecInfo@usc.edu* to reserve a space!

State Seismic Hazard Mapping Program Update

by Michael Reichle

On February 8, the Department of Conservation's (DOC) Division of Mines and Geology (DMG) released sixteen Reconnaissance Seismic Hazards Maps of parts of Los Angeles and Ventura Counties. DOC/DMG will release Preliminary and Official Seismic Hazard Zone Maps in multiple stages during the next three years. This article describes DMG's Seismic Hazards Mapping Program (SHMP), and some of the key players in the mapping and policy development arena. Next, we describe the progress on developing the guidelines, policies and criteria, and the Seismic Hazards Maps themselves. Finally, we outline current plans for release of additional products during the next three years.

The Seismic Hazards Mapping Act

After the 1989 Loma Prieta Earthquake, the State Legislature passed and the Governor signed the Seismic Hazard Mapping Act (SHMA). The intent of the Act was to establish a statewide seismic hazard mapping and technical advisory program to aid cities and counties in protecting the public from various earthquake hazards.

The framework of the Seismic Hazards Mapping Act is very similar to that of the Alquist-Priolo (A-P) Earthquake Fault Zones Act. The SHMA directs the State Geologist (Chief of DOC's Division of Mines and Geology) to issue maps showing areas where significant liquefaction, earthquake-triggered landslide, and strong ground-motion hazards exist. The A-P Act directs the State Geologist to delineate Earthquake Fault Zones.

A-P makes the State Mining and Geology Board (the Board) responsible for developing guidelines, policies and criteria relating to fault-rupture hazards. Similarly, SHMA directs the Board to develop (1) guidelines for preparation of the seismic hazard zone maps, (2) priorities for mapping the zones, and (3) policies and criteria regarding the responsibilities of cities, counties, and state agencies under the Act. These policies and criteria must address (1) criteria for approval of development projects within the zones, including mitigation measures, (2) the content of the required geotechnical reports, (3) review of the geotechnical reports by the lead agency, (4) guidelines for evaluating seismic hazards and recommending mitigation measures, and (5) processing of waivers. Unlike A-P (where the Board has sole responsibility), SHMA also directs the Board, in developing the policies and criteria, to appoint and consult with the Seismic Hazards Mapping Act Advisory Committee (SHMAAC), comprised of geologists, seismologists, civil and structural engineers, the State Insurance Commissioner, and representatives of local and regional governments and the insurance industry.

Both A-P and SHMA mandate that lead agencies require site-specific geotechnical studies, conducted by competent licensed professionals, of the mapped hazards prior to construction of most structures for human occupancy. One key difference is that A-P prohibits construction of such structures on the identified active traces of faults, whereas SHMA permits mitigation methods other than avoidance to be used.

Events to date

In 1991, the Board adopted initial guidelines and regulations based on SHMAAC's recommendations. These regulations broadly define the criteria for developing the hazards zone maps and the content of the site-specific geotechnical reports. The regulations also require each lead agency to independently review the site-specific reports to determine the adequacy of the hazard evaluation and proposed mitigation measures, specifying that the reviews be completed by a certified engineering geologist or civil engineer having competence in the field of seismic hazard evaluation and mitigation. The initial

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SHMA *continued from Page 9 ...*

guidelines provide more-detailed criteria to guide DOC/DMG in mapping liquefaction hazards. The guidelines also direct DOC/DMG to (1) develop a set of probabilistic seismic maps for California and (2) research methods that might be appropriate for mapping earthquake-triggered landslide and amplified ground-shaking hazards.

Unfortunately, that same year, DOC/DMG's Seismic Hazards Mapping Program lost two-thirds of its funding when the California Residential Earthquake Recovery Act (which accrued funding from insurance premiums) was repealed and the recession slowed construction. This reduced funding constrained DOC's early mapping efforts to development of a prototype liquefaction hazard zone map for part of San Francisco and acquisition of core components for a geographic information system needed to expedite the mapping program. The prototype map was almost ready for peer review when the Northridge Earthquake occurred in 1994.

Shortly after the Northridge Earthquake, the Office of Emergency Services (OES), with funding from the Federal Emergency Management Agency (FEMA), requested DOC to rapidly (within six months) prepare liquefaction and earthquake-triggered landslide maps covering the region most affected by the disastrous 1994 Northridge Earthquake. All Seismic Hazards Program staff and several staff from other Mines and Geology programs were assigned to prepare these maps. The maps, covering parts of Los Angeles and Ventura Counties, were delivered to OES in preliminary form in April 1995. OES used the maps in prioritizing post-earthquake hazard mitigation projects.

On February 8 of this year, slightly modified versions of the OES maps were released as DMG Open-File Report 96-01 ("Reconnaissance Seismic Hazards Maps of Portions of Los Angeles and Ventura Counties, California," 1996, by C.R. Real and others). The OFR includes sixteen (16) 1:24,000-scale blueline quadrangles plus a short report. These interim products are designed to aid cities and counties in their land-use decision-making and permitting process until the more rigorous and lengthy process of compiling Official Seismic Hazard Zone Maps can be completed. The accompanying report, also available on the World-Wide Web (see page 32), provides insights regarding development of the maps and their limitations, criteria and data sources used, and suggestions on the proper use of these maps.

How to Order DMG OFR 96-01

"Reconnaissance Seismic Hazards Maps of Portions of Los Angeles and Ventura Counties, California," 1996, by C.R. Real and others, may be ordered (prepaid) for $25.00 (check or money order in US funds; Mastercard is also accepted) from:

***California Department of Conservation
Division of Mines and Geology
801 K Street
MS 14-33
Sacramento, CA 95814***

The maps also may be purchased over-the-counter at DOC/DMG's Southern California office (107 S. Broadway, Los Angeles). MasterCard is accepted.

Current Activities and Plans for the Near Future

Following delivery of the reconnaissance maps to OES, FEMA agreed to partially fund development of Seismic Hazard Zone Maps for 38 quadrangles in Los Angeles, Orange, and Ventura Counties. DOC/DMG immediately began working on mapping seismic hazards in five of these quadrangles and accelerated development of the probabilistic seismic hazards maps for the

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An Excerpt from the Proceedings of the First Insurance Industry Workshop, November 1995

Issues with significant impact on both the private and public sectors were addressed in the November Workshop. The Proceedings, now in print and available through the SCEC Knowledge Transfer office, contains summaries of all presentations. The message delivered by Dr. Marshall Lew of Law/Crandall, Inc., a workshop session chair and SCEC Research Utilization Council member, is printed here.

Southern California's Seismic Hazard Revisited

Introduction

Publication of the SCEC "Phase II" report in 1995, reinforced by the experience of the Northridge earthquake on January 17, 1994, has resulted in a major rethinking about the seismic hazard in southern California. The "Phase II" report reinforces the earlier suspicions developed since the October 1, 1987 Whittier Narrows earthquake that there are major blind thrust fault systems beneath the Los Angeles basin. The "Phase II" report also indicates that the seismic hazard appears to greater than previously thought in this region.

The violent strong ground motions of the 1994 Northridge earthquake in the northern San Fernando Valley and the 1995 Hyogo-Ken Nanbu earthquake that affected Kobe, Japan have finally convinced the design community that earthquake ground motions in the near field of the rupture can be considerably greater than the ground motion levels assumed for design of buildings in our most seismically active areas.

Increased Seismic Hazard

Practically speaking, the "Phase II" report simply states that the seismic hazard in southern California is greater than was previously believed. Before the 1971 San Fernando earthquake, southern California had experienced just a few damaging earthquake events in the roughly 200 years since western civilization established itself here. Until 1971, the only devastating event in the Los Angeles region was the 1933 Long Beach earthquake, which resulted in more deaths than the San Fernando earthquake. However, since the San Fernando earthquake, the southland has been rattled by magnitude 5 and greater earthquakes in Point Mugu in 1973, Whittier Narrows in 1987, Sierra Madre in 1991, Landers and Big Bear in 1992, and Northridge in 1994. This year, there have been at least two magnitude 5+ events in the Ridgecrest area, north of the Mojave Desert.

Just a few years ago, there was much excitement about the possibility of “The Big One” occurring on the San Andreas fault (with a magnitude of about 8), or a moderately good size earthquake in the Los Angeles basin occurring on the Newport-Inglewood fault (with a magnitude of about 7). Today, there is evidence that the Newport-Inglewood fault is not as active and may not pose as great a threat as previously thought. Today, there is great concern about faults that may lie beneath downtown Los Angeles and extend westward along Wilshire Boulevard. Because of the “earthquake deficit,” there is talk of the possibility of having more Northridge-sized earthquakes in the near future, or the talk of one magnitude 7.0 to 7.5 earthquake in the Los Angeles basin to account for all of the apparent accumulated strain in the crust. The deep buried “blind” thrust faults are now believed to pose more hazards to southern California than the known surface faults, such as the Newport-Inglewood. Because these thrust faults are in the heavily populated and built-up areas, they present a greater hazard than the distant San Andreas fault (unless you are in San Bernardino or Redlands).

Greater Earthquake Ground Motions

Extremely strong ground shaking was recorded in the northern San Fernando Valley and in other parts of the Los Angeles basin during the Northridge earthquake. This earthquake confirmed several theories or beliefs about earthquakes. First, the Northridge earthquake conclusively demonstrated that the ground motions in the “near field” of the fault rupture can be much higher than a few kilometers away from the fault rupture zone. Second, the Northridge earthquake demonstrated that there is a directionality effect where sites in advance of the direction of wave propagation

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Feature: visit with a SCEC scientist

A Few Words with Tom Rockwell on Southern California Tectonics, Trenching, Pigmy Mammoths, and Other Topics of Interest

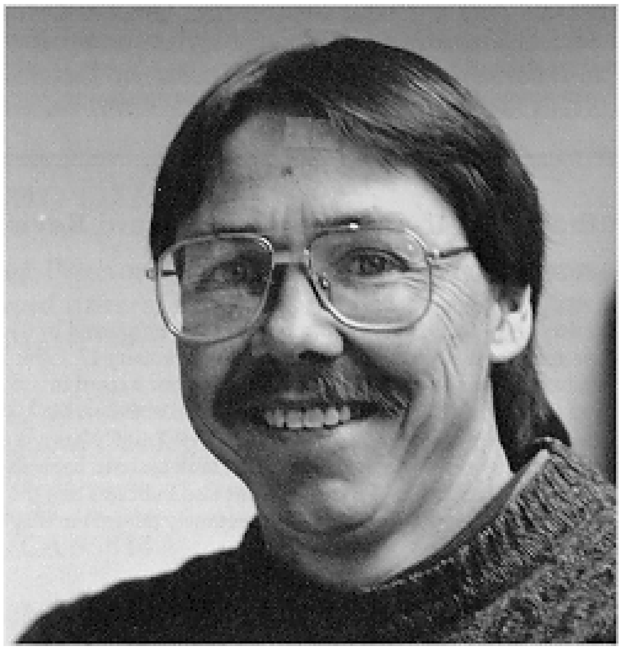
Profile

There are possibly three, maybe four people—at most—who know the tectonics of Southern California as well as Tom Rockwell. The list of faults he has received grants to trench or otherwise study include the Elsinore, San Jacinto, Imperial, Palos Verdes, Whittier, Garlock, Landers, and Rose Canyon faults; and the Compton-Los Alamitos structure. In the coming year, he plans to look at the San Cayetano, Sierra Madre, San Fernando, and Santa Susana faults. He plans to travel to both Mongolia and Israel to do similar work. (In addition to these faults, Rockwell has worked, unofficially, on many others throughout the Southland, helping various friends with their projects.)

To say that Rockwell stands at the center of an avalanche of activity is something of an understatement. In addition to his regular teaching duties, Rockwell, a professor at San Diego State University, usually oversees between ten and fifteen graduate students' research. Sit with him for an hour in his "Quaternary Lab" and the stream of visitors and calls never ceases—be it the student who needs to know what truck is being used for this weekend's outing or the archaeologist or mining geologist calling about the nineteenth project Rockwell is currently involved in. At present, he is an associate editor of the Geological Society of America's *Bulletin*, has published approximately seventy papers, and has another twenty-five in varying stages of completion.

Born October 14, 1954, Rockwell received his B.S. in Geology from the University of Nevada, Reno in December of 1976, and his Ph.D. in Geology at U.C. Santa Barbara in December of 1983. He has worked as a geologist for Dames and Moore, has held a lectureship at the California Institute of Technology, and has been a full professor at San Diego State University since 1989.

Rockwell has two sons, a fondness for four-wheel drive vehicles, sand dunes, free flight (single engine land), and is famous for his campfire guitar sing-a-long funfests from L.A. to Mongolia. He is the only person to have ever discovered a channel island pygmy mammoth's skeleton in its entirety—and in the following exclusive SCEC Quarterly Newsletter interview, reveals, for the first time anywhere, the true story of how he found it.



The Interview
by Michael Forrest, Associate Editor

MF: You've done quite a bit of work on the Whittier-Elsinore fault system and must have sat back and thought about what might happen if a really big earthquake occurred on it. So what might we see?

TR: I expect that, on a large Elsinore and Whittier rupture, we're talking about earthquakes up in the magnitude seven or seven and a quarter range—and there could be up to three or more meters of right lateral slip. If we had a Landers-type earthquake, there'd be a tremendous amount of death and destruction. Far more than what occurred out there.

Philosophically, I'm torn between the fascination between earthquake recurrence and potential for fault interaction and clustering of earthquakes, and all these different things that keep me engaged in doing this type of work, versus the tremendous potential for destruction that these faults can also produce if one

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Rockwell *continued from Page 12 ...*

happens to occur in areas that are populated.

I think we've been very fortunate. In Southern California there have been large earthquakes occurring in areas before they've been developed, or most recently up in Landers, where there's very little development.

MF: In the 1964 Alaskan earthquake, which might have been a 9+, relatively few people died. I think it was only ten or twenty. Do you think they just were lucky?

TR: Well, you have to remember that at the time, there were only one hundred to one hundred fifty thousand people in the entire state of Alaska, and probably less than fifty thousand in Anchorage. I suppose if you scaled it up to the population density of L.A., those numbers would be far more frightening.

MF: Whenever there's been a big earthquake in southern California, you always immediately jump into a car and drive off to have a look at the epicentral area. What have you've seen that surprised you most?

TR: Well, during the Landers earthquake we looked at the way non-reinforced concrete slab responded to surface rupture. It was a hybrid geology/engineering study I did with John Bray at UC Berkeley, and one of my students, Diane Murbach. We had an Earthquake Engineering Research Institute (EERI) grant to do it. We were able to go in and peel back the carpets in a house and map all the cracks in the slab, trench adjacent to the slab, look at how the faults broke up to the slab, and how that deformation was transferred through the slab. I was surprised by one guy who slept all the way through the earthquake—he didn't feel it, even though his house had been ripped in half. It was unbelievable.

Another house out there was sitting on a pressure ridge. The rupture broke on both sides of it and the pressure ridge popped up during the earthquake and basically blew the house off its foundation! Even though the house was bolted down to the slab, the quake forced the house into the air and it moved over a couple of feet. The original perimeter and slab of the house ended up outside the wall. Now one thing that amazed me about that and many other situations like it was that most of the windows in the house were left unbroken!

MF: How dangerous is the trenching of faults?

TR: I've never been *in* a trench that collapsed, but I've seen trenches that collapsed, and after a while you get a feel for when it's going to happen. You get familiar with the type of soil materials that collapse and those that don't. And you get an idea of when you need to put in twice the number of shores—even though maybe a shore every sixth foot is required by OSHA, you put a shore in every three feet to keep the trench open.

We've gone so far as to sheet the upper part of a trench with plywood and shore it, to look at the geology in the lower part, because the upper material was unstable and we didn't want any of it to rain down on us.

MF: Ever dug up something interesting in terms of artifacts or something strange?

TR: On a project in Rose Canyon, we ran across an old Indian hearth, that dated to about 9,000 years ago. It had a really nice big chopper in it, which I sent to the State archeologist for identification.

I think one of the more interesting discoveries on the Elsinore fault was a hand-molded concrete flume, that dated to the 1890s and predated the 1910 earthquake that occurred in that area. We ended up hand-excavating all the soil on top of it and it was laterally offset 25 centimeters. So we had direct evidence for

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Tom Henyey on Tom Rockwell–

"Tom Rockwell is one of southern California's preeminent neo-tectonicists and paleoseismologists. He knows more about our region's faults than any other person, and gives freely to students and colleagues, both his time and the fault-specific geological information he has garnered from years of dedicated field work. He is loved by his students and universally admired by his peers across the earth sciences."

Rockwell *continued from Page 13...*

lateral slip and surface rupture for an earthquake for which there was previously not known to be any surface rupture. But it was also in an area that wasn't very populated at the time of the earthquake.

MF: There's one idea circulating that all the Range Front faults could break at once. During Landers, you had the rupture jumping from one fault to the next...

TR: Well, it's possible for something like that to occur. Although, I don't think we've collected enough direct data to support or contradict that. I think the idea is speculative. On the other hand, the long recurrence interval that we're finding for some of these big faults does suggest that they fail infrequently—but in very large events.

MF: An 1812 event that brought down the Mission at San Juan Capistrano may have been caused by the San Andreas, or possibly the Newport Inglewood, or an offshore fault. What do you think?

TR: The offshore earthquake hypothesis was advanced before we knew that an earthquake did occur late in the growing season of 1812. So I think it's been shown that it's the San Andreas. Now you're going to say, why would the San Andreas produce so much damage in San Juan Capistrano, and there's a very simple explanation for that. There was an earthquake in October 1, 1800, which struck the coastal portion of southern California. It may have been on the Rose Canyon, or the Newport Inglewood, or further offshore. It could have been on the Elsinore, but we really don't know.

But the Mission records show that the San Juan Capistrano Mission was under construction at the time and was strongly damaged by that earthquake. And all they did was put mud in the cracks and continue building! So that mission had structural flaws in it prior to the 1812 earthquake.

Also, it's well recognized that the general design that was used for the San Juan Capistrano Mission was highly flawed. That was noted by the missionaries after the collapse. What's most telling about that earthquake is that it did not damage any of the surrounding adobe structures. It couldn't have been all that close.

MF: If there was a M=7 or an M=8 on the San Andreas in Southern California, could you envision a scenario where there was an enormous aftershock on the Palos Verdes or the Newport-Inglewood or San Jacinto, just as the Big Bear quake followed the Landers sequence?

TR: I think it's possible if any of those other faults are loaded to the point where they are ready to fail anyway. We have very limited data in the L.A. Basin on the timing of last earthquakes, but what we do have suggests that we may have some of the large faults rupturing in a very narrow time window. The Palos Verdes data is poor. But if you did plot the vertical displacement versus the age of the sediment, they cross the axis at about 1,500 to 2,000 years ago. We directly dated the last Whittier at 1,400 to 2,200 years ago and the one before that about 3,400 years ago. So at least we know for the Whittier, they're failing at every 1,500 to 2,000 years and we're basically closing in on the end of that strain cycle. Those three data points are the only data we have for the timing of large earthquakes in the late Holocene in the L.A. basin. And those two faults appear to have failed in a very narrow window, relative to how long it's been since the last earthquake. They also have about the same strain rate. It's not inconceivable that they're relatively in sync with their strain accumulation cycles.

Tom Rockwell discovered a pigmy mammoth skeleton on Santa Rosa Island in 1994. No such skeleton had ever been found intact, in its entirety. "The youngest mammoths directly dated to about 11.6 thousand years and the earliest man out there dates to 11.3 thousand years. It's unlikely we've found evidence for the very first people or the very last mammoth. So it's a pretty good bet that the last mammoths were eaten by the first people."

MF: How many events do you think you're missing, when you look at a trench?

TR: I think we could easily have a M=6.5 missing in a trench.

MF: What about a M=7?

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Rockwell *continued from Page 14...*

TR: I don't want to believe that we could have a M=7 that we couldn't see in a trench. With the Loma Prieta (which did not break the surface) we're talking about a rupture that nucleated down at seventeen or eighteen kilometers, so it was a very deep earthquake. The depth of seismicity for Palos Verdes is simply not that deep. It's only ten or twelve kilometers. So it's unlikely that, that much slip at depth, won't make it to the surface. On the Whittier fault, you have a higher chance, but what we do see from the trenching—on one of two or three strands—there is slip of at least 1.9 meters in the last earthquake. And if that slip is only half or one third of the total on the Whittier fault, then we're probably looking at three to four more meters of slip in the last earthquake. So it had to have been a large earthquake. An earthquake of that magnitude is certainly going to reach the surface. A M=6.5, I don't know—but a M=7+ would.

MF: You discovered a mini-mammoth?

TR: The *mammuthous exilous*. The channel islands pigmy mammoth.

MF: How did you find it?

TR: I'd gone down to look at marine terraces on Santa Rosa Island to look for fossil localities. We were collecting corals from the terraces to date them—basically doing a transect along the coast. I was standing in a little canyon right next to the coast by a seacliff,

Right and Below: Excavating the mammuthous exilous, or pigmy mammoth, Santa Rosa Island.

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Rockwell *continued from Page 15...*

and I spied the skeleton, eroding out of a fossil sand dune.

I went over to take a look at it, determined that it was fossil, and then walked up to tell the park ranger, because it's in a national park. (The park rangers were actually checking out this cave that was on the side of this seacliff, rapelling over the edge, to see if there were any archaeological deposits in it.)

At the time, I knew it was a mammoth, because one of my Ph.D. advisors had done his dissertation out on San Miguel island and I was familiar with his work. Mammoths were the only large animals that roamed the Channel Islands during the Pleistocene. But what I didn't know was that there was no other full skeleton found of a pigmy mammoth. I'd seen the skeleton in the Santa Barbara museum, and that is actually a composite of many dozens of different animals. So this was a unique find, and caused a lot of media attention. I found it on June 29, 1994 . We spent nine days in August, taking it out of the ground.

MF: Did they evolve out there or did they swim out there and get stranded?

TR: Well, both. During the Pleistocene, when sea level was low, the distance from the mainland was only about five miles. In fact all the islands out there were connected into one super island called Santa Rosa. On the mainland, it would have looked like another mainland to the elephants because it was over 110 kilometers long, and only a few kilometers offshore. Elephants are excellent swimmers. Elephants have been known—off India and Ceylon—to swim some twenty or thirty miles out. There are plenty of accounts of elephants swimming long distances. They'll cross major rivers in Africa. There's one case where a circus ship went down along the eastern seaboard, thirty miles off the coast, and the only animals that made it ashore were the elephants.

So they swam out to an island when they were big. Mammoths stood 14 feet. Then, the sea level rose, and the island's area shrank. In fact, it's only about 10% of the area it was 20,000 years ago. So decreasing habitat causes significant stress on a small population of elephants or mammoths. And that tends to favor the smaller guy, who doesn't need to eat as much. So with time, smaller forms evolve. It's well known that large animals evolve to smaller forms on an island, and small animals tend to evolve to a larger form.

In the Mediterranean there were ten or twelve islands that supported pigmy elephants. A full grown pigmy elephant on one of the islands, stood two feet at the shoulder. These were directly related to the elephants in Africa or India.

However, we find evidence for really big mammoths on the island as well. Probably every time the sea level dropped there was an influx of big mammoths out to the Channel Islands. The mammoths lasted until about 11.5 thousand years ago. The youngest mammoths date to about 11.6 thousand years and the earliest man out there dates to 11.3 thousand years. It's unlikely we've found evidence for the very first people or the very last mammoth, so it's a pretty good bet that the last mammoths were eaten by the first people.

MF: What are you working on now and what's coming up?

I think one of the main problems to resolve in the L.A. Basin is to find out how much strain is present on the major system of north-dipping faults that bound the San Gabriel Mountains. These are the Sierra Madre, the San Fernando and Santa Susana faults off to the west. We plan to study that system. I'll be working with Scott Lindvall (Harza-LRB) and Charlie Rubin (University of Washington). I'll be doing some work with Jim Dolan (USC) in the Ventura Basin on the San Cayetano fault, which was the focus of my Ph.D.

> ***Kim Thorup, SDSU Geology graduate student, on Tom Rockwell:***
>
> ***"His enthusiasm is really his hallmark—and he infects his students with that enthusiasm. I think the best things I've heard about him are from students who've been here, gone into industry and then came back—and realized how exciting working with him really is."***

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Rockwell *continued from Page 16...*

dissertation. I'll probably start looking at the Verdugo fault this year as well.

I'll continue to do some work in the Salton Trough and on the Garlock Fault with Sally McGill (California State University, San Bernardino). New interests this year include projects in Israel, Turkey and Mongolia.

TR: Wasn't the geometry of the faults for a double quake in Mongolia similar to that of the San Andreas and the Sierra Madre faults? Wasn't there a huge quake on a thrust fault that relieved stress on an adjacent strike-slip fault—which then broke?

TR: That's not really what happened there in 1957, because the main focal mechanism was mostly strike-slip. So really it looks like it started on the strike-slip fault. If you look at the details of both faults that ruptured in the Gobi-Altai earthquake, the Bohg fault makes a number of major jogs that require significant shortening. The shortening is essentially accommodated on the south side of the range on these big thrust faults. So, to make a comparison with the San Andreas fault is probably not as clean as it sounded at first, because the San Andreas is relatively straight, adjacent to the Sierra Madre. It doesn't make big jogs like the Bohg fault does.

MF: How did you get into Geology?

TR: I started off as an engineering major and became bored. I took a couple of geology classes for fun. I suppose my root interest in geology stems from my mother, who collected rocks—and still does. We used to go out in the desert on family trips and we would collect rocks, so I've always had a rock collection. ♦

Mitch Bornyasz, SDSU Geology graduate student, on Tom Rockwell:

"He's willing to help you. He has no problem sitting down with you and explaining what the best approach to solving the problem would be. He's got people working on almost every fault there is in this area. If not currently—he's already worked on them or has trenching lined up. I think that's why he attracts a lot of students who are interested in paleoseismology and neotectonics."

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SCEC Scientists' Publications

The complete SCEC scientists' publications listing is updated and available on a continuous basis. Please contact the SCEC Administrative Office, 213/740-1560, to obtain updated listings. Selected publications may be available through the Center. The Spring quarterly newsletter includes all publications; subsequent issues will include newly submitted papers only. Publications are in alphabetical order by principal author.

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Southern California Earthquake Center Knowledge Transfer Program

The SCEC administration actively encourages collaboration among scientists, government officials, and industry. Users of SCEC scientific products (reports, newsletters, education curricula, databases, maps, etc.) include disaster preparedness officials, practicing design professionals, policy makers, southern California business communities and industries, local, state and federal government agencies, the media, and the general public.

Knowledge transfer activities consist of end-user forums and workshops, discussions among groups of end users and center scientists, written documentation and publication of such interactions, and coordination of the development of end user-compatible products.

Products and Projects include:

- Report from the 1995 Research Utilization Council Workshop
- Insurance Industry Workshops; Proceedings; Audio tapes
- Engineering Geologists' Workshops; Proceedings; Geotechnical Catalog.
- Vulnerability Workshops, City and County Officials
- Media Workshops
- Field Trips
- Quarterly newsletter
- "Putting Down Roots in Earthquake Country" Handbook
- WWW SCEC Home Page
- SCEC-Sponsored Publications; Scientific Reports

For more information on the Knowledge Transfer Program, contact Jill Andrews, phone 213/740-3459 or Mark Benthien, 213/740-1560; e-mail "ScecInfo@usc.edu" or "jandrews@coda.usc.edu".

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constructive interference of the earthquake waves arriving at the same point at the same time. These effects are particularly strong for the types of ground motions that might affect tall buildings, or buildings that have longer fundamental periods of vibration; sometimes these effects are referred to as "fling" representing the large displacements that could occur, especially near the rupturing fault. Third, the Northridge earthquake showed us that sites on deep alluvial basins can be subjected to stronger ground motions because of earthquake waves being trapped in the basins; this effect is similar to water sloshing back and forth in a bathtub.

Some of these effects were also observed in Kobe, Japan. We already knew from the Mexico City experience of 1985 that soft soils sites were extremely vulnerable to strong ground motions, even when the earthquake is distant.

The recordings of ground motion in the Northridge earthquake showed that the levels of motions that are assumed in the design of buildings may underestimate actual ground motions. The ground motions recorded in the northern San Fernando Valley and the Santa Clarita Valley were extremely vigorous. Some engineers have commented that it was very fortunate that the strongest motions were directed to the north and not to the south; otherwise, there could have been more substantial structural damage to the high-rise buildings that are more predominant in the southern part of the San Fernando Valley. Nevertheless, many of the steel moment frame buildings in the southern part of the San Fernando Valley suffered distress at their welded connections.

What's Going to Happen?

As a result of these recent observations, changes in the building code and design practice are happening. The Structural Engineers Association of California (SEAOC) has prepared and submitted a major code change proposal to the International Conference of Building Officials (ICBO) for consideration in the 1997 edition of the Uniform Building Code.

Among the code changes in the SEAOC proposal is one change that would add a "near fault" factor; this factor recognizes that ground motions near fault ruptures are higher than away from the rupture zone. Depending on the distance from the site to the fault, the design levels could be increased 50 to 90 percent higher than present code levels; how much increase would also depend on the relative fault activity. Buildings near very active faults such as the San Andreas or San Jacinto faults would be penalized more than buildings near less active faults such as the Newport-Inglewood fault. A potential short-coming of this proposed code change is that it does not adequately address the ground motions that could come from earthquakes resulting from buried "blind" thrust faults. The reason for this is that the locations and activity rates of these faults are still unknown.

Another proposed code change would be to increase the design levels for high rise buildings and long period structures to account for the possible "fling" effects. Although unrelated to the level of ground motion, the future code is proposed to reward buildings with redundant lateral force resisting systems and regular floor plans. Many modern buildings have sacrificed redundancy in these systems to provide more open floor space and fewer obstructions; also the race to win architectural awards and make the cover of Architectural Digest has caused buildings to have

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Insurance Industry Workshop Proceedings and Audio Tapes Available

The November 9-10 SCEC Insurance Industry Workshop results and proceedings are available free of charge to participants of the workshop, and can be obtained by others through SCEC. Cost for the 95-page booklet is $15.

Audio tapes: Are available from both the first (November 1995) and second (April 1996) workshops. All tapes are fully guaranteed for exchange or refund. 1-Tape Sets (one tape per Workshop Session) are $4. Tapes may be ordered separately, or complete sets (12 tapes) may be ordered for $45 total. Shipping charges are not included.

To order proceedings and/or tapes, contact SCEC's Knowledge Transfer office.

SCEC Knowledge Transfer
University of Southern California
Mail Code 0742
Los Angeles, CA 90089-0742
phone 213/740-1560
e-mail: *ScecInfo@usc.edu*

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irregular plans thus making it difficult for structural engineers to design efficient systems to transfer seismic loads to the ground.

Effect on Construction

Continuing earthquake research will impact construction in southern California. As it is now apparent that current design and construction standards do not fully address the earthquake hazards of the region, there will be an added cost to construct and maintain buildings.

Higher design loadings specified by the building code ordinarily means that structures will have to be stiffer and stronger. Unfortunately, stiffer and stronger buildings also attract more forces, making design more difficult.

For existing construction, the higher design loads mean that older buildings most certainly will not conform or meet the new building code requirements. The higher design loads will undoubtedly cause many older buildings to not even come close to compliance with the new code levels. From past experience, it is known that many classes of existing construction are vulnerable to less than desirable performance during earthquakes. The Northridge earthquake demonstrated that there is no indestructible building material, as failures were experienced in timber, concrete and steel construction.

There are current and proposed retrofit ordinances for unreinforced masonry construction throughout California. Deficiencies in tilt-up construction have been noted and corrective measures have been proposed. The next major class of construction to receive attention is pre-1976 reinforced concrete construction, which is generally nonductile and would not be able to accommodate higher earthquake forces. There is on-going research to solve the problems identified in steel welded connections, but complete answers may still be a few years away.

These developments have sparked new interest in energy dissipation devices that are installed in buildings to reduce the earthquake-induced forces. Seismic base isolation has been implemented in several newer buildings in southern California; these include: the Foothill Communities Law and Justice Center in Rancho Cucamonga; the USC University Hospital in East Los Angeles; the Los Angeles County Fire Command Center and Emergency Command Center, both in East Los Angeles; the Kaiser Permanente Data Processing Center in Corona; and the Ambulatory Care Center at Martin Luther King, Jr./ Charles Drew Medical Center in Willowbrook. There have been several existing buildings that have been retrofitted with seismic base isolation to reduce the earthquake loads in the superstructure: Rockwell International Building in Seal Beach; Hughes Aircraft Building in El Segundo; and Kerckhoff Hall at UCLA. Several other notable buildings are planned to be or are being retrofitted with base isolators: Veterans Administration Medical Center in Long Beach and Los Angeles City Hall. Despite the promise of enhanced seismic performance, several researchers from SCEC have identified that such isolated structures may be vulnerable to large displacements that are possible in Los Angeles basin earthquakes.

There are also other forms of energy dissipation devices such as friction dampers and hydraulic dampers that are being considered because of their ability to reduce the earthquake forces in building elements by transforming the earthquake energy to heat and expelling it to the environment.

Conclusion

The research of SCEC and other groups is leading to a better understanding of the seismic regime in which we are living. These advances stimulate academic and industrial research to develop appropriate mitigation strategies for new and existing construction. ♦

World Wide Web: Miscellaneous Information

A table of preliminary **geodetic leveling results** is now available either by WWW or anonymous ftp. A brief description of the data is provided in the distribution file:

WWW URL - ***http://aladdin.gps.caltech.edu/hudnut/hudnut.html***
anon ftp - ***tango.gps.caltech.edu /pub/hudnut/prelim.level***

Contact Ken Hudnut, USGS - Pasadena, e-mail *hudnut@seismo.gps.caltech.edu* for more information.

The National Information Service for Earthquake Engineering (NISEE) at the EERC, UC Berkeley, announced that the 1971-1983 **Abstract Journal in Earthquake Engineering** is now converted to machine-readable form. WWW URL -

http://www.eerc.berkeley.edu

Contact Katie Frohmberg, e-mail: *katie@eerc.berkeley.edu* for more information.

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three-county area. DOC/DMG based the probabilistic maps on a modified SCEC model, retaining the salient features of the program and building upon it. The liquefaction and earthquake-induced landslide zone maps use site-specific sub-surface data obtained from city, county, state and federal files, coupled with basic geologic mapping by DOC/DMG and USGS.

Late last fall, SHMAAC was reactivated. Chaired by Bruce Clark (Leighton and Associates), SHMAAC established three working groups (one each for liquefaction, earthquake-triggered landslides, and amplified ground shaking), plus a Planning and Implementation Working Group. These Working Groups are reviewing the prototype maps, recommending any needed changes in mapping techniques. The Working Groups also are developing more-detailed guidelines covering the site-specific geotechnical reports, local government review of those reports, and mitigation of identified hazards.

It appears likely that the first six Preliminary Seismic Hazard Zone Maps, covering five Southern California quadrangles plus part of San Francisco, will be issued for public review and comment on July 1, 1996. Barring unforeseen difficulties, draft guidelines for statewide use should be released for public comment during mid-July. After a required 90-day comment

DOC/DMG via World Wide Web and FTP

DOC/DMG has begun to make a variety of general and technical information available via the Internet. The intent is to make many of the final SHMP products available electronically. In addition, DOC will make draft products available for review and comment via the Web. Here are some key web addresses to watch:

Department of Conservation Home Page:

http://www.consrv.ca.gov/

DOC is the parent agency to the Division of Mines and Geology, State Mining and Geology Board, Division of Oil and Gas, Division of Recycling, and Office of Land Conservation.

Department of Conservation's Division of Mines and Geology Home Page:

http://www.consrv.ca.gov/dmg/

This page has links to descriptions of DOC/DMG's mission and programs; resources of interest to geologists, engineers, planners, educators, and the public; the SHMP Home Page; and DMG's FTP site.

Seismic Hazards Mapping Program Home Page:

http://www.consrv.ca.gov/dmg/shezp/

This page has links to the Seismic Hazards Mapping Act, current Zoning Guidelines adopted by SMGB, and related regulations; text of DMG OFR 96-01 (Reconnaissance Seismic Hazards Maps); information on map availability; and other related resources. Copies of draft Guidelines, when issued, will be available via this link later this year.

DOC/DMG FTP Site:

ftp://ftp.consrv.ca.gov/dmg

This site currently has data from DOC/DMG's Strong-Motion Instrumentation program and some DEM's for California. The DMG plans to add digital products from the Seismic Hazard Mapping Program and other DOC/DMG programs in the near future.

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period, the Board will adopt updated guidelines and/or regulations. If these time frames can be met, the first six Official Seismic Hazard Zone Maps will be released on January 1, 1997. On April 1, 1997, another ten (10) Preliminary Maps will be released for review and comment. Twenty-three (23) Preliminary Maps will be released about January 1, 1998. In all cases, Official Maps will supersede the Preliminary Maps and be released six months later. We plan to supplement these basic products with technical reports that describe the data and techniques used to develop the maps, digital databases, digital versions of the maps, and various explanatory materials (articles, brochures, etc.).

Funding for the Seismic Hazards Mapping Program continues to be a major concern. DOC is working on a variety of fronts to secure a stable source of funding sufficient to complete mapping of high-priority areas (about 265 7.5-minute quadrangles in the State) over a ten-year period. Unless the present funding situation changes, DOC/DMG will have to restrict its hazard mapping effort to the declared three-county Northridge Earthquake disaster area until at least January 1, 1998. ♦

SMIP96: A Seminar on Seismological and Engineering Implications of Recent Strong-Motion Data

Purpose

The purpose of the Seminar is to provide state-of-the-art data and analysis results from recent research studies of strong-motion data from the California Strong Motion Instrumentation Program (SMIP). The Seminar is the eighth in a series of annual events designed to transfer recent research findings on strong-motion data to practicing seismic design professionals and earth scientists. The goal is to provide information that will be useful immediately in seismic design practice and, in the longer term, in the improvement of seismic design codes and standards.

Place and Date

May 14, 1996, 9 am - 5 pm
Radisson Hotel, Sacramento
500 Leisure Lane
Sacramento, CA 95815
916/922-2020

Registration

Call 916/278-4960
Pre-registration fee is $65 after May 6.

Proceedings

Seminar proceedings, including all technical papers, will be provided to participants at the Seminar.

Sponsor

Strong Motion Instrumentation Program
Division of Mines and Geology
California Department of Conservation
801 K Street, MS 13-35
Sacramento, CA 95814-3531
916/322-3105

The Earthquake Center Hosts Earthquakes and Insurance II

The Southern California Earthquake Center Knowledge Transfer program hosted *Earthquakes and Insurance II*, April 17-18, 1996, the second conference in a series designed to promote information exchange among insurance and reinsurance business professionals, risk analysis consultants, and earthquake scientists and engineers.

Feedback from over 200 participants in the first workshop in November, 1995, indicated SCEC should dedicate this conference to the education of scientists and engineers in insurance fundamentals; explain how insurance professionals underwrite and evaluate earthquake as a cause of physical loss; and provide scientists and engineers the information needed to improve the evaluation process.

The first day of the conference coincided with a SCEC technical seminar. Attendees heard “Insurance Basics for Scientists and Engineers” by Mr. Robert Nagaishi, Eden Park Insurance Brokers, Inc. Mr. Nagaishi provided a glossary of insurance terms (to be included in the conference proceedings) that are generally accepted in the insurance community, and introduced key terms needed to understand the underwriting thought process. He defined the purpose of insurance, in general, and property insurance specifically; and discussed property underwriting concepts, familiarizing participants with underwriting process for catastrophic causes of loss, or as the process relates to earthquakes.

The technical seminar was led by Dr. David Jackson, SCEC Science Director and Professor of Geophysics at UCLA. Entitled “The ‘Earthquake Deficit’ and the Stability of the Earthquake Rate in California,” the half-day seminar included talks by Dr. Lucile M. Jones (USGS Pasadena)–”Variations in the rate of Small (M>3) Earthquakes in Southern California”; Dr. Volodya Keilis-Borok (UCLA)–Intermediate-term Earthquake prediction in Southern California; Dr. Charles Sammis (USC Earth Sciences Chairman)–”Understanding Earthquake Clustering in Space and Time”; Dr. Anthony Crone (USGS Denver, CO)– “The Temporal Variability of Surface-Faulting Earthquakes in Stable Continental Regions—A

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Paleoseismic Perspective"; Dr. Bill Ellsworth (USGS, Menlo Park)–"Time-varying seismicity rates and their relationship to changes in the state of stress"; and Dr. Lynn Sykes (Lamont-Doherty Earth Observatory)–"Changes in rates of occurrence of moderate to large shocks before great earthquakes: Is such a long-term precursor underway in southern California?"

The second day, the opening address was delivered by Dr. William Petak (USC; Director, Institute for Safety and Systems Management; Member, SCEC Advisory Council). His talk, "Insurance and Natural Hazard Mitigation: Issues and Perspectives," will be published in the conference proceedings. Three main sessions followed: The first, moderated by Mr. Dennis Doyle of American Reinsurance, covered the Insurance and Reinsurance Businesses—and answered questions such as "Who are the Principals in the area of earthquake insurance?"; "How are they organized?"; "What are their roles in relation to each other and in relation to their clients?" and "What tools or models do they use in assessing risk?"

The second session, moderated by Mr. Robert Downer, Farmer's Insurance Group and insurance chair for the Seismic Safety Commission, covered information, data, tools, and knowledge which scientists and engineers can capably contribute to the earthquake insurance process. A compelling summary statement was made by Eugene Lecomte, CEO, Insurance Institute for Property Loss Reduction. Mr. Lecomte's comments were directed toward forming a coalition that will promote the mitigation of losses resulting from earthquakes. During his speech, which will be published in the proceedings, Lecomte suggested that forming a coalition could reduce deaths, injuries and property damage that otherwise would occur.

The third session, moderated by Mr. Richard Roth (California Department of Insurance) and Jill Andrews (SCEC Knowledge Transfer), was an open forum discussion with expected next steps; linkages; and suggestions, questions, and responses form the audience. A panel of scientists, engineers, and insurance representatives responded to the questions. Earthquake Center representatives Tom Henyey, David Jackson, and Jill Andrews concluded that the Center would continue to provide tools for earthquake hazard and risk estimation, while providing information and usable knowledge through an ongoing seminar series for insurance and reinsurance professionals. They suggested pursuing Lecomte's idea to partner with stakeholders in the community to encourage the formation of a coalition to reduce losses from earthquakes, while handing off public policy issues to organizations and entities charged with those responsibilities.

> ***"...an incentive for stakeholders to participate in coalitions involves the fact that through their involvement, they preclude the potential of not having their voice heard; their knowledge and expertise weighed; and their recommendations considered or acted upon."***
>
> **Eugene Lecomte, IIPLR**

A proceedings volume from the November workshop was recently published and contains the full text of the feedback obtained through use of the Crawford Slip Method, as well as expanded abstracts and papers by all presenters. A second proceedings from *Earthquakes and Insurance II* will be published in the next few months. To obtain copies of the proceedings, or audio tapes of either or both the events, please contact the SCEC Knowledge Transfer office: phone 213/740-1560; fax 213/740-0011; e-mail ScecInfo@usc.edu. ♦

SCEC 1996 Calendar

May
10 Los Angeles Tall Buildings Structural Design Council Annual Meeting, Los Angeles, CA. Call Lisa Dixon, 213/362-0707 for more information.
14 SMIP 96, Radisson Hotel, Sacramento, 500 Leisure Lane, Sacramento, CA 95815, for more information, call Strong Motion Instrumentation program, Division of Mines and Geology, California Dept. of Conservation, Sacramento, 916/322-3105.
15-17 Wharton Financial Institutions Center, University of Pennsylvania will host a conference entitled "Risk Management in Insurance Firms." Papers are currently solicited. Contact: E. Tatum, ph 215/753-5838; fax 215/573-8757; e-mail *tatume@wharton.upenn.edu*.
16 SCEC Technical Seminar: Subject and venue to be announced. Call 213/740-5843 for details.
20-24 American Geophysical Union Annual Meeting, Baltimore, MD. Contact American Geophysical Union, 202/464-6900 for more information.

June
10-11 Third Annual Congress on Natural Hazard Loss Reduction, Dallas, Texas, sponsored by the Insurance Institute for Property Loss Reduction. For registration information, call 617/722-0200, ext. 223.

July
7-10 Natural Hazards Research and Information Center Annual workshop, Denver, CO. Call 303/492-6818 for more information.
19 All-day SCEC-sponsored field trip with , and Dr. Tom Rockwell, Dr. Lisa Grant, and Mr. Eldon Gath. We will tour the Whittier/ Elsinore and Newport-Inglewood Fault zones. Call 213/740-1560 for more information.
July 29-August 2 Pan Pacific Hazards Conference, Vancouver, British Columbia, Canada. Look for the SCEC poster. For more information, contact Disaster Preparedness Resources Centre, university of British Columbia, 2206 East Mall, 4th Floor, Vancouver, B.C. V6T 1Z3, CANADA. Phone 604/822-5518, fax 604/822-6164; e-mail: *dprc@unixg.ubc.ca*.

August
27-29 SCEC Site Review with Center Steering Committee and Board of Directors.

September
16-20 Western States Seismic Policy Council Annual Meeting, Polson, MT. Contact Fred Naeher, Montana Disaster and Emergency Services, phone 406/444-6982.

October
19-21 SCEC Annual Meeting, Riviera Resort and Racquet Club, 1600 North Indian Canyon Drive, Palm Springs, CA 92262-4602. Call 213/740-5843 for more information.
20-22 Association of Contingency Planners (ACP) National Symposium, San Antonio, Texas. Call 512/463-3950 and ask for Tommye White for more information.
25 SCEC-Sponsored field trip with Dr. Tom Henyey and Dr. Tom Rockwell. We will spend the day inspecting the Palos Verdes fault zone. For more information, call 213/ 740-1560.
28-November 1 Geological Society of America (GSA) Annual Meeting, Denver, CO. Call 303/447-2020 for more information.

December
6-8 SCEC-Sponsored Field Trip with Dr. Kerry Sieh. We will inspect the southern San Andreas Fault system. We'll begin in San Bernardino and head south, ending up in Palm Springs Friday evening. Don't miss this opportunity to learn more about the largest fault in California! Call 213/740-1560 for more information.
16-20 American Geophysical Union Annual Meeting, San Francisco, CA. Call 202/464-6900. Venue to be announced.

Earthquake Information Resources On Line

SCEC World Wide Web Home Page

SCEC WWW URL
http://www.usc.edu/dept/earth/quake

Cruising the Internet? Check out the new SCEC WWW Home Page.

Here is a sample list of what you'll see:

Home Page:
"What is SCEC?"--a summary of the Center's history and purpose, including a description of the Master Model concept.
"Formal Mission"--Mission statement and list of Working Groups and Leaders, with links to more detailed descriptions of the research conducted by each of the groups.
"Organization"--a classic organizational chart which shows, at a glance, the structure of the Center.
"Research"--a layer accessible through the home page and the "Mission" page, with detailed descriptions of each Working Group's research to date.

The page also features links to:

- SCEC Core Institutions
- SCEC Infrastructure Facilities--such as the SCEC Data Center at Caltech; the SCEC GPS Centers at UCLA and Scripps Oceanographic Institute; and the Portable Broadband Instrument Center at UCSB.
- SCEC Outreach Programs
- SCEC Products--such as the earthquake hazard analysis map; the Quarterly Newsletter; and SCEC Publications List.
- "Surfing the Net for Earthquake Data"

Jill Andrews

SCEC on the Internet

SCEC Knowledge Transfer and Education Programs are now reachable via electronic mail.

Ask general questions, make requests, send us information for use in our resource center or for consideration for publishing in the next newsletter.

ScecInfo@usc.edu

Other WWW Sites for Exploration

General/Reference
- Yahoo: General internet index
http://www.yahoo.com
- Internet Search (via Netscape Corporation)
http://home.netscape.com/home/internet-search.html
- WWW Viewer Test Page (ensure that your browser will work)
http://www-dsed.llnl.gov/documents/WWWtest.html

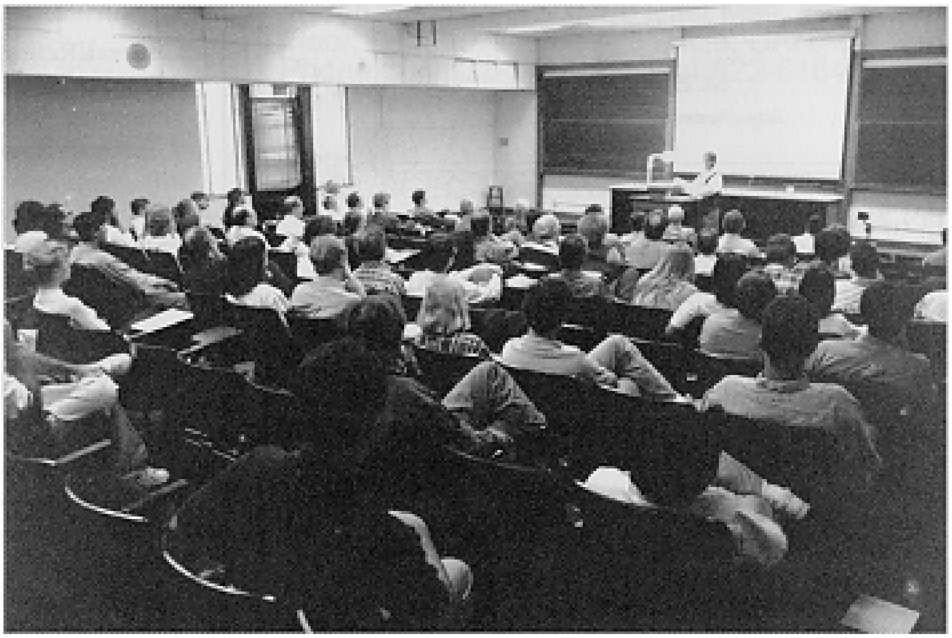
Earthquakes and Seismology
- Yahoo - Earthquakes section
http://www.yahoo.com/Environment_and_Nature/Disasters/Earthquakes
- Seismo-surfing the Internet
http://www.geophys.washington.edu/seismosurfing.html
- USGS - Menlo Park (Earthquake info, past and current)
http://quake.wr.usgs.gov/ or *http://info.er.usgs.gov/*
- Recent Quakes (with a great map viewer)
http://www.civeng.carleton.ca/cgi-bin/quakes
- Kobe shaking (color photo of shaking intensity)
http://quake.wr.usgs.gov/QUAKES/shake/kobe/kobeshake.html

Engineering and Preparedness
- NCEER (National Center for Earthquake Engineering Research)
http://nceer.eng.buffalo.edu/
- Earthquake Engineering Research Center (EERC)
http://nisee.ce.berkeley.edu/
- Structural Engineers Association of California
http://www.power.net/users/seaoc-ad/
- Earthquake Hazard Maps (ABAG Searchable maps)
http://www.abag.ca.gov/bayarea/eqmaps/eqmaps.html
- Emergency Preparedness Info Exchange
http://hoshi.cic.sfu.ca/~anderson
- Federal Emergency Management Agency (FEMA)
http://www.fema.gov
- California Office of Emergency Services
http://www.oes.ca.gov/8001
- Other Civil Engineering Servers
http://www.civeng.carleton.ca/Other-Civil.html

Peter Clark and Katie Frohmberg
UC Berkeley
Earthquake Engineering Research Center

SCEC Technical Seminar News

SCEC Scientists Kerry Sieh (California Institute of Technology) and Leon Knopoff (University of California at Los Angeles) hosted a technical seminar at Caltech March 21, 1996. "Earthquake Repetitions: Regularities and Irregularities in Space and Time" was the topic of the afternoon seminar. Speakers included Dr. Tom Rockwell (San Diego State University), "Temporal Clusters of Large Earthquakes in Southern California;" Dr. Harold Magistrale (San Diego State University), "Segmentation of the San Andreas fault in San Gorgonio Pass;" Dr. Didier Sornette (University of California at Los Angeles), "Statistical physics of fault patterns: Are Faults Optimal Structures?"; Dr. Steve Ward (University of California at Santa Cruz), "Dogtails versus Rainbows: Synthetic Rupture Models as an Aid in Interpreting Geological Fault Slip Data;" Dr. Steve Day (San Diego State University), "Simulating Rupture of Complex Fault Zones;" and Dr. Leon Knopoff, "Heterogeneous Fault Models Geometry vs. Physics?" ♦



Above: Kerry Sieh leads discussion.

EERI Announces Conference on Economic Impacts of Earthquakes

As part of its cooperative agreement with FEMA, EERI will be holding a conference on October 10-11, 1996, on **Analyzing Economic Impacts and Recovery from Urban Earthquakes: Implications from Research on the Northridge Event.** The conference will focus on issues of relevance to policy makers, and will be organized around four commissioned papers:

*Public and Private Capital Losses of the Northridge Earthquake;
*Indirect Economic Losses of Northridge;
*Financial Sector Response in Northridge;
and,
*The Future Scenario; What might LA recovery look like with limited federal assistance and "mini" insurance coverage?

There will also be a number of panelists speaking on their Northridge-related research, and respondents who will react to the research results presented. All presentations will be made in plenary sessions, delivered over a day and a half.

The conference will be held at the Doubletree Hotel in Pasadena, CA. To be placed on a mailing list for further information about the conference, fax or e-mail your request to the EERI office:

Fax: 510/451-5411
E-mail: *eeri@eeri.com.*

Southern California Earthquake Center Administration

SCEC Board of Directors

Putting Down Roots in Earthquake Country: Order While They Last!

If you live in southern California, you can get your copy of the layman's version of the "Seismic Hazards in Southern California–Probable Earthquakes, 1994-2024" at your local library. Organizations (both profit and non-profit) can arrange for large quantities through the Southern California Earthquake Center by calling the phone number below.

The 32-page, full-color handbook, authored by seismologist Lucile M. Jones of the U.S. Geological Survey, explains the risks southern Californians face from earthquakes–and what can be done about it.

Call 213/740-1560 and order now while supplies last!

Seismic Hazards Report Now Available

Reprints of Seismic Hazards in Southern California: "Probable Earthquakes, 1994 - 2024," published in the April edition of the *Bulletin of the Seismological Society of America*, is available through the SCEC Administrative Offices. Copies, which include color figures and maps, are $5 each.

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