Executive Office

County of Los Angeles
CHIEF ADMINISTRATIVE OFFICE
713 KENNETH HAHN HALL OF ADMINISTRATION • LOS ANGELES, CALIFORNIA 90012
(213) 974-1101
http://cao.co.la.ca.us

DAVID E. JANSSEN
Chief Administrative Officer

April 16, 2004

To: Supervisor Don Knabe, Chairman
Supervisor Gloria Molina
Supervisor Yvonne Brathwaite Burke
Supervisor Zev Yaroslavsky
Supervisor Michael D. Antonovich

From: David E. Janssen
Chief Administrative Officer

KEILIS-BOROK EARTHQUAKE PREDICTION FOR SOUTHERN CALIFORNIA

During the April 13, 2004 Board meeting, Supervisor Antonovich reported on a UCLA research effort that had resulted in the prediction of a 6.4 magnitude earthquake striking in southern California during the next five months. This memo is in response to a request by Supervisor Antonovich which instructed the Chief Administrative Office, Office of Emergency Management, to report back in one week concerning the contents of that report and the appropriate public information measures the County should take.

Dr. Vladimir Keilis-Borok, a UCLA Seismologist, and colleagues have issued an earthquake prediction for a magnitude 6.4, or above, earthquake to occur in Southern California within the period of October 29, 2003 to September 5, 2004. The 12,440 square mile area of southern California includes portions of the eastern Mojave Desert, Coachella Valley, Imperial Valley (San Bernardino, Riverside and Imperial Counties) and eastern San Diego County. See attached copies of the Short-Term Advance Prediction report, which includes the current prediction (Attachment 1), and a Science News Article (Attachment 2).

The California Earthquake Prediction Evaluation Council (CEPEC) of the Governor's Office of Emergency Services issued a report dated March 2, 2004 regarding their evaluation of the Keilis-Borok earthquake prediction. The CEPEC report concluded that, due to the lack of validity, **"the results do not warrant any special public policy actions in California"**. However, CEPEC recommends that all jurisdictions review and periodically exercise existing preparedness and response plans.

CEPEC also recommends that citizens who live in areas of high seismic hazard should take all general preparedness actions recommended by emergency management organizations and the Red Cross (see Attachment 3).

A summary report from Dr. Lucy Jones, U. S. Geological Survey, dated February 3, 2004 also states that the prediction has limited applications and that they are unable to make any definitive statements (see Attachment 4). However, Dr. Jones states that "It's always good to be prepared."

The County continues to provide Operational Area (OA) leadership in emergency planning and preparedness. The Office of Emergency Management (OEM) has been active in promoting earthquake preparedness through its Emergency Survival Program (ESP) public education campaign. Numerous publications, in English and Spanish, are available and can be accessed through the ESP website at www.espfocus.org, or by calling the ESP hotlines at (213) 974-1166 (English), or (213) 974-2217 (Spanish). The ESP information is also contained on the County website for easy access by County employees. OEM continues to conduct annual OA emergency exercises to test the preparedness levels of our County departments and the 88 cities that comprise the OA. Our motto is *"Los Angeles County – Prepared Today and Even More Prepared Tomorrow".*

To ensure good communication on this subject, I will send a memo to all department heads informing them of the Keilis-Borok Prediction and reminding them to continue to use the ESP information on the www.espfocus.org website, to review their Department Emergency Plans, and to encourage their employees to attend the Civic Center Employees Earthquake and All-Hazards Emergency Preparedness Expo on April 29, 2004.

I also want to make you aware that NBC television has scheduled a four-hour disaster epic miniseries entitled "10.5" about a cataclysmic earthquake that rocks California. It is scheduled to air on May 2 and 3, 2004. Although the premise is unrealistic and there is no scientific basis for the storyline, the miniseries may generate some constituent interest.

We see this as an opportunity to stress the importance of being prepared for earthquakes and other hazards; therefore, I want to encourage your staff to refer callers to our ESP website to receive a full array of preparedness information.

I will provide you with any other updates or information as appropriate. Please contact me if you have any questions regarding this matter, or your staff may contact Constance Perett, of my Office of Emergency Management, at (323) 980-2261.

DEJ:CP
JH:cm
Attachments

c: Executive Officer, Board of Supervisors
County Counsel
Emergency Management Council
Board Emergency Preparedness Deputies

Short-Term Advance Prediction of the San Simeon Earthquake, California, December 22, 2003, Magnitude 6.5

V. Keilis-Borok, P. Shebalin
E-mail: vkb@ess.ucla.edu; shebalin@mitp.ru

Here we report a successful advance prediction of the recent San Simeon earthquake in central California, magnitude 6.5, December 22, 2003. This prediction was communicated to a group of leading experts* on June 21, 2003, six months prior to the earthquake.

This is the second successful advance prediction made during a recently initiated test of a new methodology; the first advance prediction was made for a large earthquake on Hokkaido, Japan, magnitude 8.1 that happened on September 25, 2003.

We also report that an earthquake with magnitude 6.4 or above is anticipated in an area in southern California by September 5, 2004.

Successful prediction. Figure 1 illustrates the successful prediction of San Simeon earthquake, M6.5, 12/22/2003. It shows precursory chain of earthquakes (red circles); an earthquake with M6.4 or above is expected within the gray area by 02/28/04; the epicenter of the San Simeon earthquake is shown by blue star.

Current prediction. Figure 2 shows the territory in southern California where an earthquake with magnitude 6.4 or above is expected within the period 10/29/03 – 09/05/2004.

Methodology. Qualitatively, the precursor is a chain of medium magnitude earthquakes that occurred close in time and space and quickly extended over a large distance (red circles in Figs. 1, 2). A precursory chain is detected by a recently introduced methodology named "Reverse Detection of Precursors" (*RDP*), in which short-term precursors are considered in conjunction with intermediate-term ones (appearing years in advance), in the reverse order of their appearance. *RDP* allows detecting precursors not detectable in direct analysis. This methodology is based on the concept of self-organization of the fault network culminated by a strong earthquake. Highly promising among intermediate-term precursors is a geodynamical one reflecting interactions between ductile and brittle layers of the crust.

The ongoing test covers territories of Japan, California, and East Mediterranean. While the test is by no means complete, the first results are highly promising for earthquake prediction research and for disaster preparedness.

---

* A report "On the current state of the lithosphere in Central California" was sent to J. Dewey, B. Ellthworth, J. Filson, M. Ghil, J. Healy, T. Jordan, L. Knopoff, V. Kossobokov, J. McWilliams, W. Mooney, F. Press, B. Romanovicz, G. Schubert, A. Soloviev, D. Turcotte, J. Vidale.

The team. The described methodology of short-term prediction is being developed by the following team: K. Aki[5], A. Gabrielov[3], A. Jin[4], V. Keilis-Borok[1,2], Z. Liu[2], T. Nagao[6], O. Novikova[1], N. Tsybin[7], S. Ueda[6], P. Shebalin[1,5], I. Zaliapin[1,2].

Collaborating institutions:

[1]International Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Ac. Sci., Moscow;
[2]Institute of Geophysics and Planetary Physics and Department of Earth and Space Sciences, University of California at Los Angeles;
[3]Purdue University;
[4]Association for Development of Earthquake Prediction, Tokyo;
[5]Institut de Physique du Globe de Paris;
[6]Earthquake Prediction Research Center, Tokai University;
[7]Russian Federal Research Institute for Aviation Systems, Moscow.

Acknowledgement: This study was made possible by the 21st Century Collaborative Activity Award for Studying Complex Systems, granted by the James S. McDonnell Foundation and by International Science and Technology Center (Project 1538). The staple of our work are the earthquake catalogs, laboriously, timely and competently compiled by Japanese Meteorological Agency (*JMA*), Advanced National Seismic System (*ANSS*), Southern California Earthquake Data Center (*SCEDC*), Geophysical Institute of Israel (*GII*). JMA catalog was received through the Japan Meteorological Business Support Center.

References:

1. Short-term advance prediction of the large Hokkaido earthquake, September 25, 2003, magnitude 8.1: A case history. (2003) Report. http://www.geocities.co.jp/Technopolis/4025/030925eq.pdf

2. Reverse detection of short-term earthquake precursors. (2003) Submitted to *Phys. Earth and Planet. Inter.* Arxiv/physics/0312088 (http://arxiv.org/abs/physics/0312088)

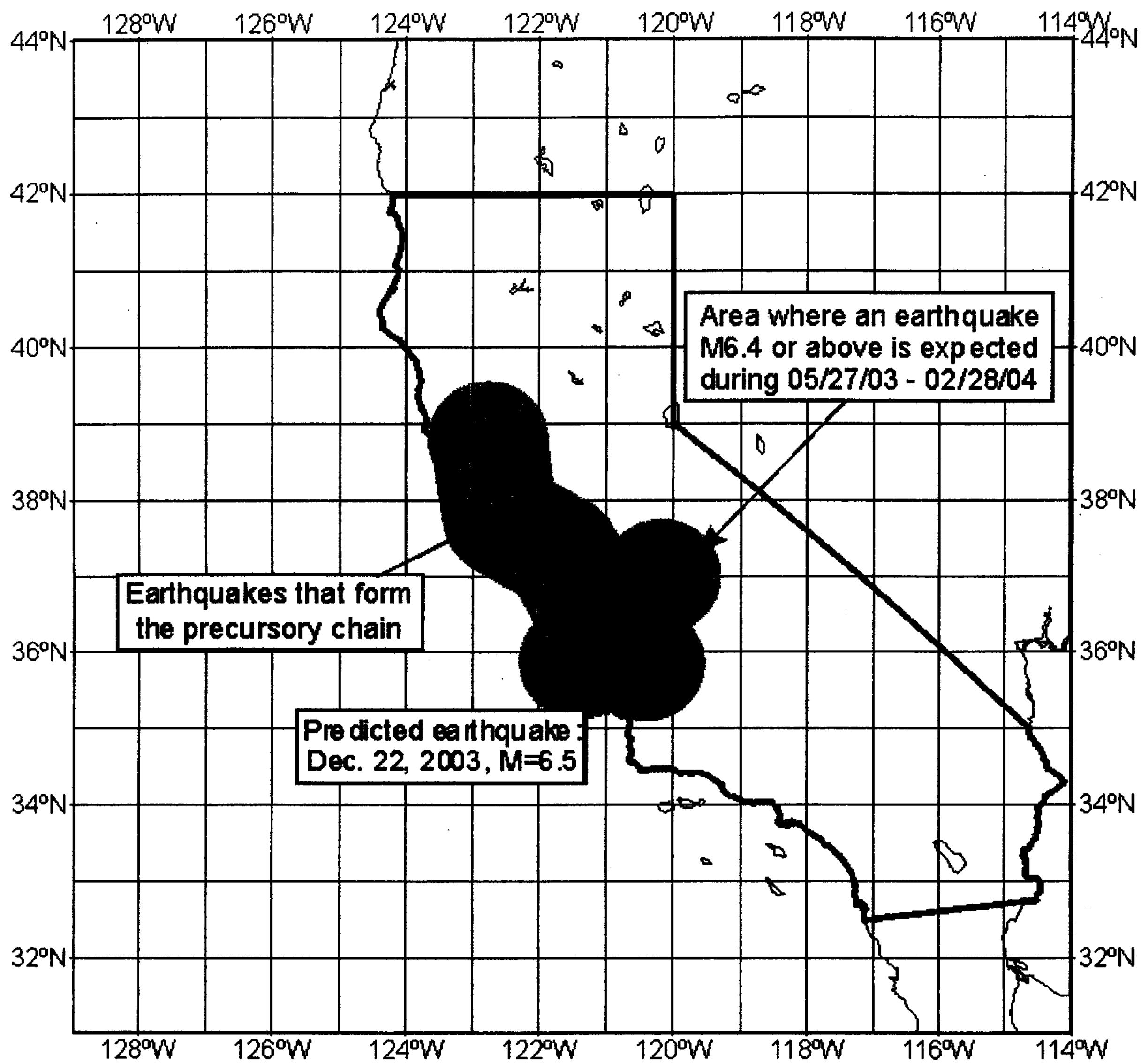


Figure 1. Successful prediction of San Simeon earthquake (Dec. 22, 2003, M6.5). Earthquakes that form the precursory chain are shown by red circles; an earthquake with magnitude 6.4 or above is expected within gray area by Feb. 28, 2004; the epicenter of San Simeon earthquake is shown by blue star.

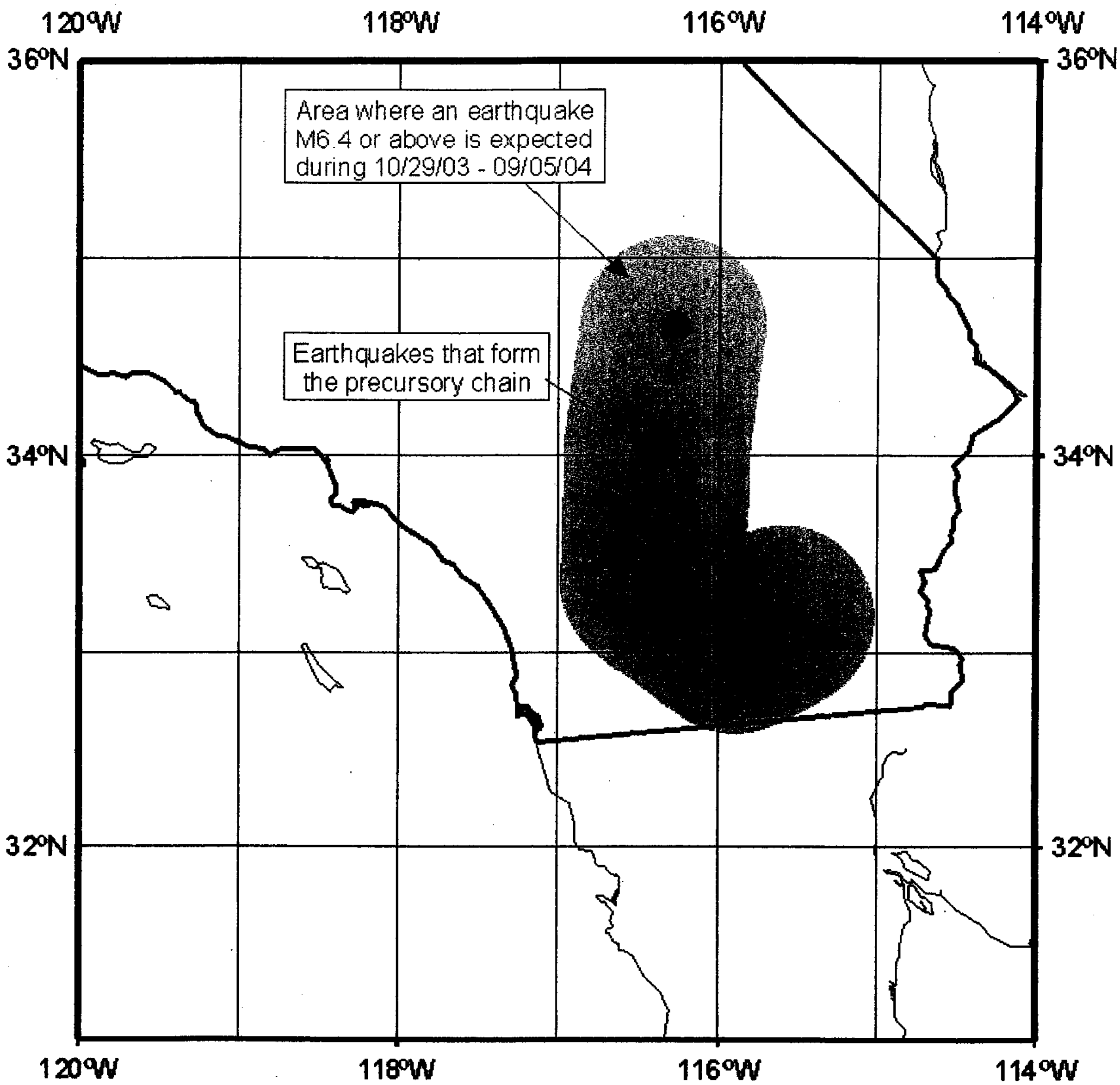


Figure 2. Current prediction.

An earthquake with magnitude 6.4 or above is expected within the gray area within the period Oct. 29, 2003 – Sep. 05, 2004. Red circles show the earthquakes that formed the precursory chain.

Earthquake Prediction Experiment Forecasts 6.4 or Higher in SE Calif. By September 5

UCLA group does not attach a probability estimate to their forecast.

Science News Article on this subject

(KFWB) 1.20.04, Updated 11:20am -- Dr Thomas Jordan, Director of the Southern California Earthquake Center, told an emergency managers' meeting in downtown Los Angeles Friday afternoon that a UCLA group was making an "intermediate term prediction" of an earthquake that could affect a broad area of Southern California. Here is the UCLA news release on the forecast (see map below as well, courtesy of the Southern California Earthquake Center):

Major earthquakes can be predicted months in advance, argues UCLA seismologist and mathematical geophysicist Vladimir Keilis-Borok.

"Earthquake prediction is called the Holy Grail of earthquake science, and has been considered impossible by many scientists," said Keilis-Borok, a professor in residence in UCLA's Institute of Geophysics and Planetary Physics and department of earth and space sciences. "It is not impossible."

"We have made a major breakthrough, discovering the possibility of making predictions months ahead of time, instead of years, as in previously known methods," Keilis-Borok said. "This discovery was not generated by an instant inspiration, but culminates 20 years of multinational, interdisciplinary collaboration by a team of scientists from Russia, the United States, Western Europe, Japan and Canada."

The team includes experts in pattern recognition, geodynamics, seismology, chaos theory, statistical physics and public safety. They have developed algorithms to detect precursory earthquake patterns.

In June of 2003, this team predicted an earthquake of magnitude 6.4 or higher would strike within nine months in a 310-mile region of Central California whose southern part includes San Simeon, where a magnitude 6.5 earthquake struck on Dec. 22.

In July of 2003, the team predicted an earthquake in Japan of magnitude 7 or higher by Dec. 28, 2003, in a region that includes Hokkaido. A magnitude 8.1 earthquake struck Hokkaido on Sept. 25, 2003.

Previously, the team made "intermediate-term" predictions, years in advance. The 1994 Northridge earthquake struck 21 days after an 18-month period when the team predicted that an earthquake of magnitude 6.6 or more would strike within 120 miles from the epicenter of the 1992 Landers earthquake - an area that includes Northridge. The magnitude 6.8 Northridge earthquake caused some $30 billion in damage. The 1989 magnitude 7.1 Loma Prieta earthquake fulfilled a five-year forecast the team issued in 1986.

Keilis-Borok's team now predicts an earthquake of at least magnitude 6.4 by Sept. 5, 2004, in a region that includes the southeastern portion of the Mojave Desert, and an area south of it.

This map is posted through the courtesy of The Southern Califormia Earthquake Center, which has no association with the UCLA group's prediction.

The team has submitted a description of its new short-term earthquake prediction research to Physics of the Earth and Planetary Interiors, a leading international journal in geophysics.

Prediction by this method is based on observations of small earthquakes that occur daily.

"We call our new approach, 'tail wags the dog,'" Keilis-Borok said. "For example, I recently had a sharp pain in a small area of my arm. The doctor sent me for an MRI to test whether this pain was preceded by an unfelt deterioration of the muscles in the whole arm during the last few months. If yes, the pain signals that the deterioration has escalated, so I am in trouble, and need urgent medical treatment. If not, I may have just hit something, the pain will subside, and it's of little concern. To detect these symptoms in order of their appearance - first emerged, first detected - could seem more natural but it is much more difficult; we would not know when and where to look for long-term deterioration.

"Similarly, we look backwards to make our earthquake predictions. First, we search for quickly formed long chains of small earthquakes. Each chain is our candidate to a newly discovered short-term precursor. In the vicinity of each such chain, we look backwards, and see its history over the preceding years - whether our candidate was preceded by certain seismicity patterns. If yes, we accept the candidate as a short-term precursor and start a nine-month alarm. If not, we disregard this candidate."

In seismically active regions, the Earth's crust generates constant background seismicity, which the team monitors for the symptoms of approaching strong earthquakes. Specifically, they consider the following four symptoms: small earthquakes become more frequent in an area (not necessarily on the same fault line); earthquakes become more clustered in time and space; earthquakes occur almost simultaneously over large distances within a seismic region; and the ratio of medium-magnitude earthquakes to smaller earthquakes increases.

One of the challenges in earthquake prediction has been to achieve a high proportion of successful predictions, while minimizing false alarms and unpredicted events. The team's current predictions have not missed any earthquake, and have had its two most recent ones come to pass.

Still, not all seismologists are convinced. "Application of nonlinear dynamics and chaos theory is often counter-intuitive," Keilis-Borok said, "so acceptance by some research teams will take time. Other teams, however, accepted it easily."

Keilis-Borok, 82, has been working on earthquake prediction for more than 20 years. A mathematical geophysicist, he was the leading seismologist in Russia for decades, said his UCLA colleague John Vidale, who calls Keilis-Borok the world's leading scientist in the art of earthquake prediction. Keilis-Borok is a member of the National Academy of Sciences, and the American Academy of Arts and Sciences, as well as the Russian Academy of Sciences, and the European, Austrian and Pontifical academies of science. He founded Moscow's International Institute of Earthquake Prediction Theory and Mathematical Geophysics, and joined UCLA's faculty in 1999.

His research team has started experiments in advance prediction of destructive earthquakes in Southern California, Central California, Japan, Israel and neighboring countries, and plans to expand prediction to other regions.

Vidale, interim director of the Institute of Geophysics and Planetary Physics, said, "Most seismologists agree that the ingredients of the 'tail wags the dog' method are sensible, but argue about the performance. However, the proof is in the pudding, and Professor Keilis-Borok's methods have now delivered several correct and impressive forecasts."

At the most recent stage of the research, four members of the team worked at UCLA on the "tail wags the dog" method for short-term prediction: Keilis-Borok; Peter Shebalin, geophysicist from the Russian Academy of Sciences and Institute of the Physics of the Earth in Paris; Purdue University mathematician and geophysicist Andrei Gabrielov; and UCLA researcher Ilya Zaliapin, whose field is analysis of complex systems.

Keilis-Borok's team communicates the predictions to disaster management authorities in the countries where a destructive earthquake is predicted. These authorities might use such predictions, although their accuracy is not 100 percent, to prevent considerable damage from the earthquakes - save lives and reduce economic losses - by undertaking such preparedness measures as conducting simulation alarms, checking vulnerable objects and mobilizing post-disaster services, Keilis-Borok said.

During the last few years, the team was supported by the James S. McDonnell Foundation.

How does Keilis-Borok compare this research with other discoveries he has made over his scientific career?

"I think this is the strongest result we have obtained so far," he said.

Report to the Director, Governor's Office of Emergency Services
By the California Earthquake Prediction Evaluation Council
March 2, 2004

The Governor's Office of Emergency Services requested that the California Earthquake Prediction Evaluation Council meet to evaluate an earthquake prediction proposed by Dr. Vladimir Keilis-Borok and colleagues. The Council met on February 20, 2004.

The prediction is for a magnitude 6.4 or greater earthquake to occur on or before September 5, 2004, within a 12,440 sq. miles area of southern California that includes portions of the eastern Mojave Desert, Coachella Valley, Imperial Valley (San Bernardino, Riverside and Imperial Counties) and eastern San Diego County (Figure 1).

The area of the southern California prediction includes a number of very active faults, including the Coachella segment of the San Andreas fault, the southern portion of the San Jacinto fault, the Imperial fault, and a portion of the Elsinore fault. Based on the geologic recurrence rates and the dates of previous earthquakes, earth scientists generally agree that both the Coachella segment of the San Andreas fault and the Anza segment of the San Jacinto fault are areas where large earthquakes are likely in the near future (1995 report of the Working Group on California Earthquake Probabilities). The area is one of the most seismically active in the state. It includes the recent Landers (M7.3) and Hector Mine (M7.1) earthquakes, which continue to have significant aftershock activity. There were 8 earthquakes with $M \geq 6.4$ in the area of the southern California prediction during the last 60 years of the 20th century. The probability of a $M \geq 6.4$ earthquake occurring in a random 9-month period is thus estimated to be about 10% (see Technical Note1, below).

The Keilis-Borok et al. method is based on identifying patterns of small earthquakes prior to large shocks. Technical details of the prediction methodology are summarized in Technical Note 2.

In mid-2003, the Keilis-Borok group issued two earthquake predictions using variants of this methodology, one for a $M \geq 7.0$ earthquake in a 250,000 sq. mi. area that includes the northern part of the Japanese islands and one for a $M \geq 6.4$ earthquake in a 40,000 sq. mi. area that includes portions of central California. These two predictions were satisfied by the September 25, 2003 Hokkaido and December 22, 2003 San Simeon earthquakes, respectively. CEPEC notes that these were "proper" predictions, in that the authors specified in advance the area, time interval, and magnitude range satisfied by the subsequent events. However, the authors did not provide formal estimates of the probability gain over random occurrence with their predictions (see Technical Note 3). The Japan prediction area is very seismically active; 12 $M \geq 7.0$ earthquakes occurred in this area during the 30 years from 1974 through 2003, which yields a 30% probability for a random occurrence. The central California area has been much less active; only three $M \geq 6.4$ events (1906 San Francisco, 1983 Coalinga, and 1989 Loma Prieta) have occurred during the last hundred years, and 6 to 7 in the last 150 years. Therefore, the probability of a M≥6.4 earthquake in the specified area during a random 9-month period is about 2% to 5%.

The Keilis-Borok methodology appears to be a legitimate approach in earthquake prediction research. However, the physical basis for the prediction put forward by the authors has not been substantiated, and they have not yet issued enough predictions to allow a statistical validation of their forecasting methodology. Continued research along these lines may lead to useful forecasts. Although the analysis has matured to the point of generating provocative scientific results, the absence of an established track record and the sensitivity of the results to input assumptions leaves CEPEC uncertain of the robustness of the prediction made using patterns of small earthquakes.

This uncertainty along with the large geographic area included in the prediction (about 12,400 sq. mi.) leads CEPEC to conclude that the results do not at this time warrant any special public policy actions in California. Nevertheless, the southern California prediction, as well as the recent San Simeon earthquake, should serve to remind all Californians of the significant seismic hazards throughout the state. Regardless of the validity of the prediction, CEPEC recommends that all jurisdictions review and periodically exercise existing preparedness and response plans. Likewise, citizens of California who live in areas of high seismic hazard should make sure they have undertaken all general preparedness actions recommended by emergency management organizations and the Red Cross.

Technical Notes

1. The best estimate of 10% assumes earthquakes occur randomly in time; i.e., according to a Poisson process. Under this assumption, the 90% confidence interval for the estimate is 4-18%.

2. The Keilis-Borok et al. prediction for southern California is based on identifying patterns of small earthquakes ("chains" of M≥2.9 earthquakes) that have been observed to precede M≥6.4 earthquakes in California. Chains that are large enough (more than 6 events spanning more than 175 km) are tested using a retrospective analysis that searches for precursory patterns of seismicity during the preceding 2-5 years. If a chain "qualifies" by having a high enough score in terms of these possible intermediate-term precursors, a prediction is issued for the 9-month interval immediately following the last event of the chain. In the case of the southern California prediction, the chain comprised 10 earthquakes, and the last event occurred on December 5, 2003.

3. From the retrospective analysis of the California earthquake catalog for 1965-2003, the Keilis-Borok group derived a false-alarm rate of about 33% (5 out of 15 qualified chains were false alarms), and they claimed no failures to predict. An analysis restricted to southern California yielded a false-alarm rate of 13% (1 in 8 qualified chains was a false alarm). The associated probability gains were a factor of about 10 and 12 over random occurrence, respectively. In the case of the Japan prediction, the retrospective false- alarm rate was 41% (7 of 17), and the probability gain was a factor of about 7. All of these statistics are subject to large errors; moreover, they are likely to be biased toward optimistic values, because the prediction algorithm was tuned to optimize the retrospective analysis.

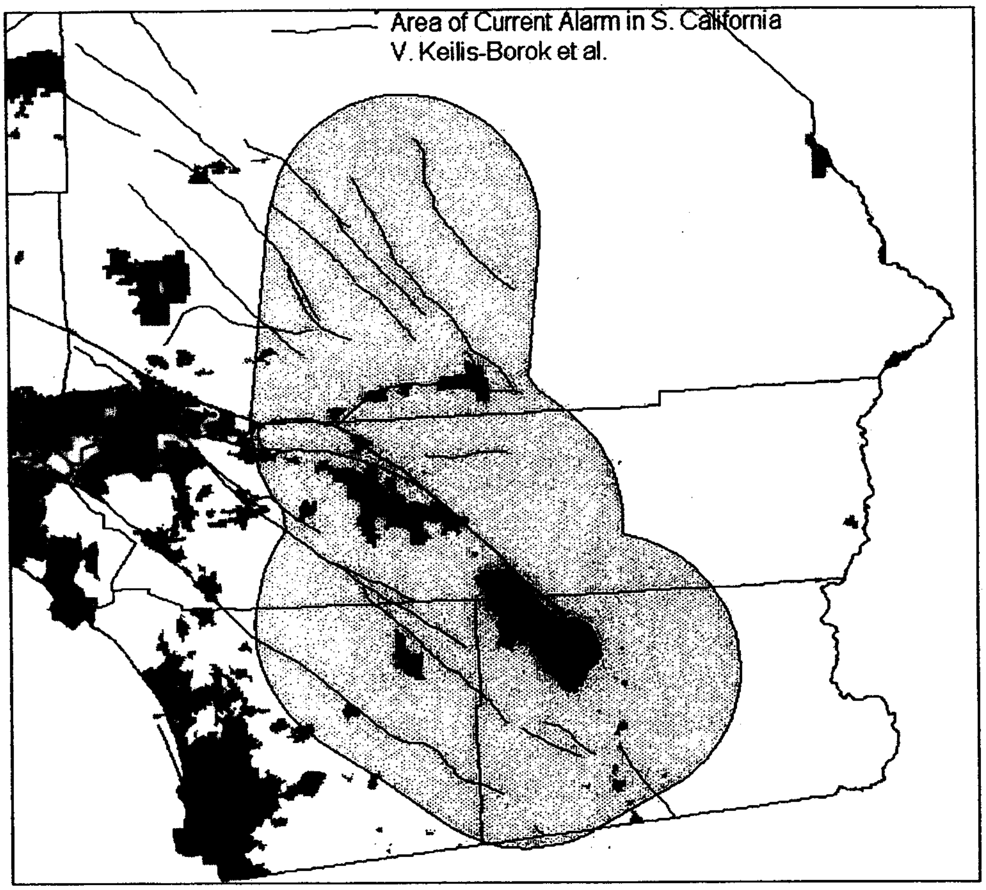
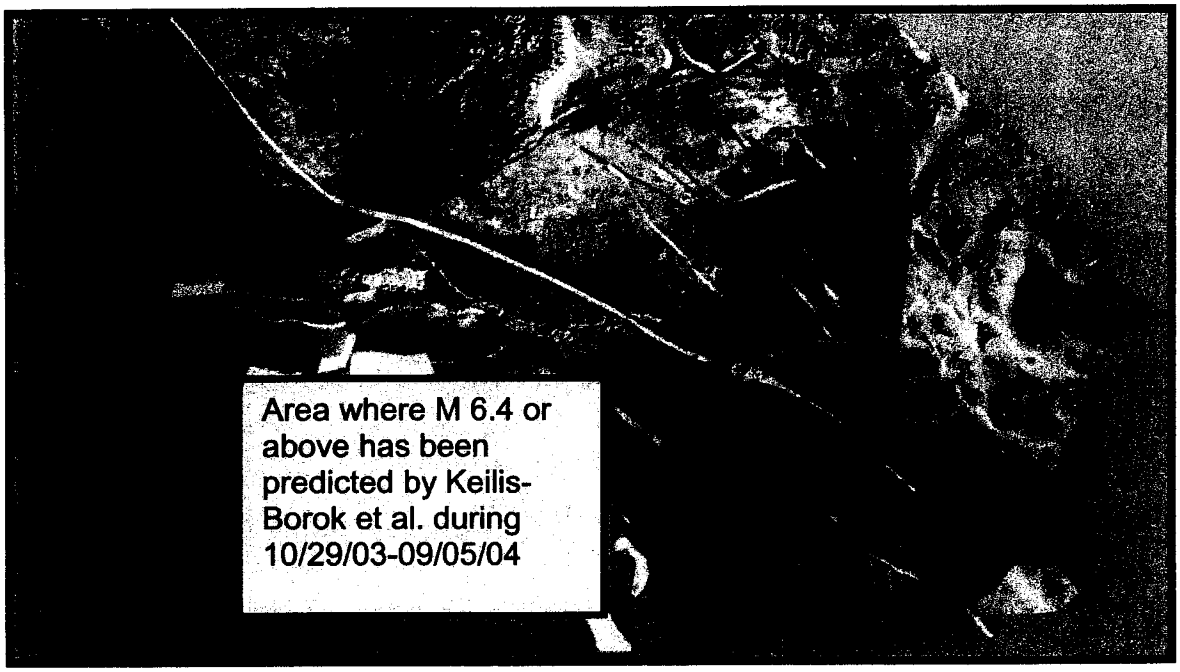


Figure 1.

Current Earthquake Prediction for Southern California
Summary from Dr. Lucy Jones, US Geological Survey, Scientist-in-charge for Southern California and Commissioner, California Seismic Safety Commission
February 3, 2004

Dr. Vladimir Keilis-Borok, a member of the Russian and American National Academies of Science, and a long-time researcher in earthquake prediction has developed a new algorithm with which he is attempting to predict earthquakes. He has made public announcements of three predictions. All have had time frames of 9 months and areas spanning at least 200 miles. The first was for a M≥7.0 in northern Japan that was fulfilled by the July 2003 Hokkaido (M8.1) earthquake. The second was for a M≥6.4 earthquake in central California that was fulfilled by San Simeon earthquake. The third is for a M≥6.4 in the shaded are of the figure below before September 5, 2004.



The prediction is based on a statistical analysis of recorded small earthquakes, and not based on a physical model of how earthquakes occur. Thus the validation of the prediction will be from statistics. The two successful predictions suggest that this technique may have some validity but we are still looking at too small a sample to be able to make any definitive statements. The scientific community will be evaluating the technique over the next few weeks and providing a report to the Governor's Office through the California Earthquake Potential Evaluation Council.

On a social level, the prediction has limited application involving as it does such a large area and long time window. Many active faults are recognized in the area with very different consequences. To help demonstrate, the following pictures show the expected areas of strong shaking for some of the possible earthquakes on the known faults in the area.

Scenario shaking intensities for some of earthquake sources in the 1996 USGS National Hazard Maps

Computed using OpenSHA, the ShakeMap attenuation relation for MMI and site effects from Wills. Labeled by fault and assumed magnitude.