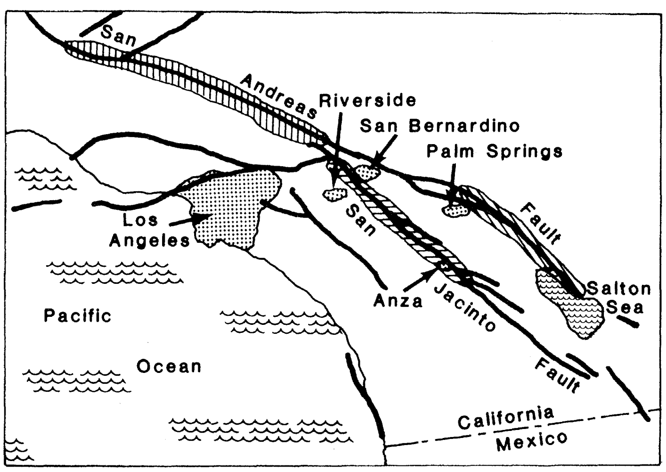
—Research News—

Pinning Down the Next Big California Quake

Seismologists, geologists, and historians have agreed on three locations where the next large southern California earthquake might strike

On the assumption that history repeats itself, southern California has been bracing for another great earthquake like the one that broke more than 300 kilometers of the San Andreas fault near Los Angeles in 1857. But now it is clear that a long length of fault can vary its behavior by breaking one segment at a time or by forming a new combination of subdivisions that break at once. Or, as was made clear in Mexico last month, a fault can lie dormant so long that it might appear harmless. Researchers aiming to predict the next large southern California earthquake are now focusing on three fault segments: the southern section of the 1857 break north of San Bernadino; the northern San Jacinto fault, a side branch of the San Andreas running through San Bernadino; and part of the far southern San Andreas, a segment that has not broken in recorded history. None of these segments has yet been equipped with instruments to the extent thought necessary to maximize the chances of predicting the next large earthquake.

Some faults to watch



Three fault segments (highlighted with crosshatching) are the new focus of attention in southern California. There is no historical record of the San Andreas segment just north of the Salton Sea breaking, but the geological record shows it to be active. The highlighted segment to the north was part of the 1857 break. Much of the northern San Jacinto has broken during this century.

The clearest statement of the new consensus comes from the meeting last spring of the National Earthquake Prediction Evaluation Council (NEPEC) (*1*), a group of experts that advises the U.S. Geological Survey (USGS). The most clear-cut threat comes from the southern section of the 1857 break, called the Mojave segment, which passes within 50 kilometers of downtown Los Angeles and terminates 20 kilometers north of San Bernadino. The crust on the western side of the fault slipped 3 to 6 meters past the eastern side of the fault in 1857. Since then, that fault segment has been locked tight while freely moving segments have slipped 4.5 meters. That much stored energy could be released as an earthquake of at least magnitude 7.5. The magnitude of the 1857 event was about 8.2.

Kerry Sieh of the California Institute of Technology has dug trenches across the Mojave segment at Pallet Creek to reveal the disruption of soft sediments caused by a sequence of large earthquakes. At least 12 have broken this segment during the past 1400 years, he found. The intervals between events have ranged from 50 years to 300 years, averaging 140 to 150 years. It is now 128 years since the last rupture. Lynn Sykes of Lamont-Doherty Geological Observatory and Stuart Nishenko of the USGS in Golden, Colorado, estimate that there is a 19 to 49 percent probability that another large earthquake will strike during the next 20 years (*2*).

The other long segment of the San Andreas receiving special attention runs between Palm Springs and the Salton Sea. Ten years ago, it might have been left out of any focused prediction effort. There had been no large earthquake on it or the adjoining San Andreas north to San Bernadino. There was some diffuse, low-level activity to the north, so that it seemed possible that motion on the San Andreas was sidestepping to the San Jacinto, a branch fault that joins the San Andreas north of San Bernadino.

The great earthquake that reduced hundreds of buildings in Mexico City to rubble in September broke a section of fault that also had been quiet an unusually long time. There were a half dozen other seismic gaps along the Mexican coast where 30 or 40 years had passed since the last large earthquake, making them appear due for another soon. But the Michoacán gap had gone at least 75 years without a large event, suggesting that perhaps it was incapable of generating one. Perhaps the way the fault slips is altered by the Orozco fracture zone that runs into the fault from offshore.

The Mexican quake showed all too clearly that that fault segment was capable of a large rupture, and now it is clear from work by Sieh that at least near Indio, midway between Palm Springs and the Salton Sea, the far southern San Andreas has produced large earthquakes about as often as segments to the northwest that have broken in historical times. Searching the historical record, Duncan Agnew of the University of California at San Diego has concluded that a large event on this segment could not have occurred since 1851, making an imminent repeat possible soon, but it is not necessarily overdue. Sykes and Nishenko find a 21 to 61 percent probability of a magnitude 7.5 event on this segment during the next 20 years.

The third focus of attention is the northern part of the San Jacinto, where about 20 percent of the motion of the San Andreas sidesteps onto this branch. Its behavior has attracted plenty of interest—it has generated more destructive earthquakes in the history of California than any other fault. One segment near Anza has attracted particular attention because it has not broken since at least 1892 and little low-level seismic activity occurs on it now, suggesting that it remains locked despite the 1 centimeter per year of motion that must be increasing the strain on it. Earthquake recurrence times are particularly uncertain on the San Jacinto, so that recurrence probabilities have wide ranges, but 20-year probabilities for segments adjacent to Anza range from 4 to 86 percent for magnitude 6.0 to 6.7 events, according to Sykes and Nishenko. Similar earthquakes have comparable chances of striking as far north as the Riverside–San Bernadino area.

Summing up NEPEC's conclusions for Dallas Peck, director of the USGS, Sykes finds that "The probability is moderate to high that a large to great (magnitude 7.5 to 8) earthquake will occur in southern California during the next 30 years." Thus, although the likely sources of the earthquake threat have shifted, the seismic hazard remains the same. Still, it does not justify a hazard warning, as recently redefined by the USGS. NEPEC recommended that the earthquake hazard watch instituted in 1980 should not be replaced by a hazard warning, the only formal notice remaining in the USGS procedures.

While informal communications are substituted for a formal watch, the USGS is studying where on these segments of the southern San Andreas and the San Jacinto detailed earthquake prediction studies such as that under way at Parkfield (*3*) might be located. Such an effort, if undertaken, would be a considerable one. The Parkfield segment of the central San Andreas, where a magnitude 5.5 earthquake is expected between now and 1992, is the most intensely monitored site in the United States, but many researchers feel that the effort there is still insufficient and should be augmented before new sites for instrument clusters are chosen.

Even as attention is being focused on a few areas in southern California, Sykes cautions that "a few other major faults" besides the San Andreas and San Jacinto could produce major earthquakes "during the next few decades." None of the three large southern California earthquakes since 1857 were on the San Andreas. And even a moderate event in the densely populated Los Angeles basin, say a magnitude 6.5 event on the Newport-Inglewood fault system, could be as destructive as a magnitude 8 on the more distant Mojave segment of the San Andreas.—**Richard A. Kerr**

References

1. C. F. Shearer, *USGS Open File Report 85–507* (minutes of the National Earthquake Prediction Evaluation Council, Pasadena, Calif., 29 to 30 March 1985).
2. L. R. Sykes and S. P. Nishenko, *J. Geophys. Res.* **89**, 5905 (1984).
3. R. A. Kerr, *Science* **228**, 311 (1985).

Chemists Seek a Higher Profile

A new National Academy of Sciences report explores the intellectual frontiers of chemistry and recommends some changes in funding

In its first full-scale survey of the chemical sciences since 1965, the National Academy of Sciences finds the field in intellectual ferment—and in danger of being taken for granted.

"Opportunities in Chemistry," is the product of 3 years' work by the 26-member Committee to Survey the Chemical Sciences, chaired by George C. Pimentel of the University of California, Berkeley.* It takes issue with a number of common perceptions of the field, starting with the idea that chemistry is a mature, stable science in which little of importance remains to be discovered. In part this perception is fostered by the existence of a mature, stable chemical industry, which carries on an immensely profitable business in petrochemicals, synthetic fibers, agricultural chemicals, and plastics. But it also arises because chemistry is the foundation for so many other disciplines: some of the most exciting work is being done in areas such as molecular genetics, immunology, and materials science, which are now regarded as independent fields by scientists and funding agencies alike.

At the same time, the report points out that chemistry has evolved considerably beyond the one lone experimenter stage. While hardly big science in the same sense as physics or astronomy, modern chemistry does qualify as a kind of "intermediate" science, in which researchers need major instruments such as picosecond lasers or even supercomputers to make progress. As a result, the survey committee concludes that the federal funding of basic chemical research needs to be improved in a number of ways.

In its first recommendation, the committee points to five areas on the intellectual frontiers of chemistry that it says deserve special attention and support:

- Understanding chemical reactivity. Using ultrafast laser spectroscopy, chemists have been able to dissect individual reactions and to follow the detailed flow of energy within molecules as they approach, interact, and move apart again. In addition, theorists using high-speed supercomputers have begun to understand these reaction dynamics from first principles. In the long run this work could pay off in new ways of controlling reactions and in the creation of whole new classes of materials.
- Chemical catalysis. Instrumentation is developing to the point where chemists can "see" molecules as they react on catalytic surfaces. Theorists are approaching a unified understanding of catalysis in all its forms. And synthetic chemists are improving their ability to tailor artificial enzymes and organometallic compounds with the desired reactivity and stereospecificity.
- Chemistry of life processes. On a molecular level, obviously, life *is* chemistry. Specifically, chemists have become deeply involved in molecular biology with the synthesis of tailored molecules such as natural product analogs, chemotherapeutic agents, and proteins altered to provide new functions.
- Chemistry around us. Analytical chemistry and reaction dynamics continue to be crucial to understanding the processes that couple the atmosphere, the oceans, the earth, and the biosphere. A famous example from the recent past is the ozone controversy, which hinged on interplay of ozone, chlorofluorocarbons, and sunlight in the earth's stratosphere.
- Chemistry under extreme conditions. In the normal course of events, a chemistry laboratory offers only a limited range of environments. In nature, however, chemical reactions take place over much wider range of conditions: extreme pressures (the interior of the earth and other planets); extreme temperatures (a reentry vehicle heat shield); in gaseous plasmas (the walls of a fusion reactor); and at superconducting temperatures.

To help pay for all this, the committee

*"Opportunities in Chemistry" (National Academy Press, Washington, D.C., 1985).