Richards at Yale, Frederick Cohen at the University of California in San Francisco, Michael Sternberg at the University of London, and David Phillips at Oxford University, is to use what is called a "combinatorial tertiary structure." They try all possible ways to put together a protein from its amino acid sequence, based on rules saying when particular sequences are likely to form helices or pleated sheets, for example. Then they examine the resulting million or so structures with the computer. Most of these potential structures are completely unreasonable. They sift through the remaining reasonable ones by using all they know about the biochemical function of the protein to decide which of the structures is most likely correct.

For example, Cohen and Sternberg tried this method for the protein myoglobin. Out of a million possible structures, only 100 were reasonable. But only two of those reasonable structures could possibly be correct because only two could bind heme groups, as myoglobin does.

The two approaches, says Kuntz, "are not a wonderful success, but they are certainly the best thing going." Kuntz, Cohen, and their colleagues Robert Langridge and Thomas Ferrin are now starting a research program that will combine protein extensions and combinatorial tertiary structures for computer predictions of protein structures.

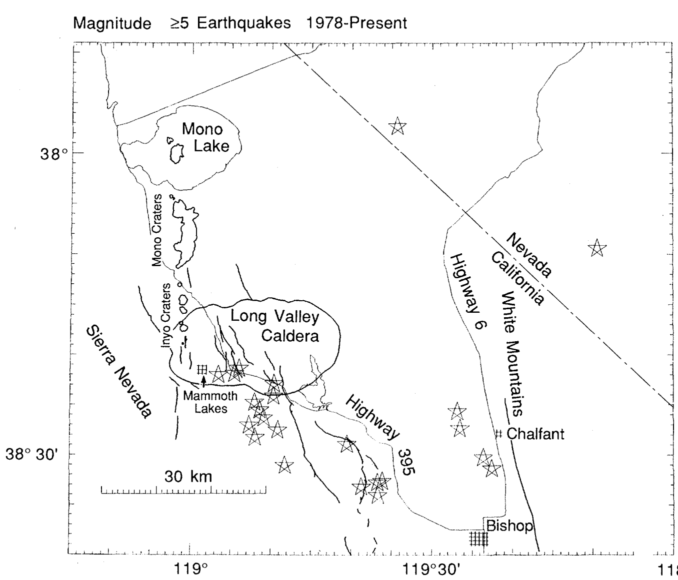
So the work continues. Everyone thinks that the protein-folding problem is worth pursuing, and even the most optimistic see no solution immediately in sight. "Nobody seems to be on the road to where they can say they will do it in 3 to 5 years," Creighton observes. "At present, there is not enough progress to say it is solved even to a first approximation," says Baldwin. "What is needed now is luck and very clear thinking." ■ GINA KOLATA

Do California Quakes Portend a Large One?

Far from the San Andreas fault, three lines of evidence hint at a large earthquake striking within the next decade

AMONG the flurry of earthquakes last month in California, seismologists took particular interest in the sequence of quakes in Chalfant Valley near the Nevada border east of Yosemite National Park. At first glance, the other shocks implied little about future events, but these eastern California earthquakes strengthened an already suggestive argument that a large earthquake of magnitude 7 or almost 8 could hit California soon. Rather than striking the closely watched San Andreas fault, the expected shock would occur on the less closely monitored but far less densely populated California-Nevada border. One of California's three great earthquakes in historic times struck just to the south in Owens Valley in 1872, followed since by three large events to the north. Geophysicists think they see signs that the next in the sequence could strike at anytime.

The case for expecting a large earthquake in the near future depends on the application of three relatively standard forecasting techniques to a new sort of locale. The most extensively applied forecasting technique is the recognition of a seismic gap—a fault section waiting to break in an earthquake. In this case the suspect fault section is near the White Mountains, just north of Bishop, California. This is about midway in a zone of seismic activity extending from southern California, where the North American and Pacific plates are sliding past each other, to north-central Nevada, where the Great Basin is being stretched apart.



D. Hill, USGS

A Mogi doughnut?

The pattern of recent seismicity in the vicinity of the White Mountains resembles the roughly circular pattern, called a Mogi doughnut, known to precede some large earthquakes. The earthquakes of magnitude 5 and greater since 1978 include the four near Chalfant this July. Heavy lines denote faults active during the past 10,000 years or volcanic features.

Although not a single, well-defined fault like the San Andreas, this seismic belt was broken by earthquakes of magnitude 6.8 and greater in 1872, 1915, 1932, and 1954, activity rivaling that on the San Andreas. Only two unbroken sections remain among these failed sections, the largest being the 130 kilometers of the belt along the White Mountains. By analogy with the way earthquakes completely rupture the faults along coastal Mexico and Japan section by section, Robert Wallace of the U.S. Geological Survey (USGS) in Menlo Park has suggested that there is a high potential for a major earthquake in the White Mountains seismic gap. Because the interval between breaks has ranged from 22 to 43 years and the last break was 32 years ago, the next break could come at anytime, Wallace reasons.

The Chalfant Valley earthquakes of last month focused attention on the White Mountains seismic gap because they enhance a pattern of moderate seismic activity encircling that gap that is familiar elsewhere as a harbinger of a large earthquake. In 1983 Alan Ryall of the Center for Seismic Studies in Arlington, Virginia, who was then at the University of Nevada, and his colleagues pointed out that since 1978 the level of moderate seismic activity in the general area of the gap had been 20 times that during the previous decade. And that heightened activity seemed to be forming a partial circle about the gap. Such circles or doughnut patterns of moderate earthquakes had formed about the sites of future large events in Japan and elsewhere, as noted by Kiyoo

Mogi of Tokyo University. The 1984 Round Valley and July's Chalfant earthquakes have since filled in more of the White Mountains pattern. A similar Mogi doughnut, as the pattern is called, appeared in the 5 years preceding the magnitude 6.8 Coalinga, California, earthquake of 1983.

A Mogi doughnut encircling a seismic gap is intriguing enough that seismologists would not be at all surprised if a large earthquake of magnitude 7 or almost 8 struck anytime within the next few years or a decade. Adding a curious twist to such forecasts is a stunning if deeply mysterious regularity in the seismic activity near the gap. In December 1984 Ryall and David Hill of the USGS in Menlo Park pointed out that the recent Round Valley earthquake was the fifth in a sequence of earthquakes that had struck every 18 months since October 1978. A simple linear extrapolation made later by James Savage of the USGS in Menlo Park called for the next significant event in the sequence, if there were one, to occur on 27 March 1986. The Chalfant swarm struck on 20–21 July, 4 months "late." Savage has now extrapolated from the six events, none of which falls more than 3 months from a single straight line, and found that the next event in such a sequence would be 7 December 1987.

This extrapolation "is not intended as a prediction," says Savage, "I don't quite believe it myself." The problem is that the only place where repetitive activity occurs that even approaches such regularity is at one spot near Parkfield on the San Andreas. Moderate earthquakes recur there about every 22 years and magnitude 3 shocks recur every 39 to 41 months. But the events of the White Mountains sequence fall on a different fault each time, making the driving mechanism of the apparent periodicity obscure indeed.

The Chalfant event "confirms the periodicity," says Savage, "but what the sequence says beyond that I don't know. If it occurred on one fault, it would be easier to understand." Asked if the next moderate shock in the sequence might trigger the large quake, Hill concedes that, mysterious or not, "as the next interval comes up, it will be hard to ignore that straight line."

The prospect of a large earthquake in the near future will not likely divert much attention to the White Mountains gap. The USGS is already heavily committed to monitoring the San Andreas, Parkfield, and nearby Long Valley, a quiescent volcanic caldera that forms part of the doughnut and had threatened to reawaken. The concepts of seismic gaps and doughnuts are rather well worked out in the case of earthquakes occurring between plates, but the White Mountains area is a geologically complex zone within a plate that is riddled with a variety of fault types. And, because of the emptiness of the land, even a large shock will not do much more damage than the Chalfant quakes. ■

RICHARD A. KERR

ADDITIONAL READING

D. P. Hill *et al.*, "Review of evidence on the potential for major earthquakes and volcanism in the Long Valley-Mono Craters-White Mountains regions of eastern California," *Earthquake Predict. Res.* 3, 571 (1985).

Washington Embraces Global Earth Sciences

For reasons of science and for reasons of strategy, the funding agencies want to study the earth as an integrated whole

On the face of it, deficit-haunted Washington is not the most promising place to be promoting a visionary new research program. And yet, just within the past year or two, a rare combination of scientific urgency and bureaucratic self-interest has led the funding agencies to embrace what may well be the largest cooperative endeavor in the history of science.

The proposal goes under a variety of names, including Global Geosciences at the National Science Foundation (NSF), Earth Systems Science at the National Aeronautics and Space Administration (NASA), and the International Geosphere-Biosphere Program at the National Academy of Sciences. But each name expresses the same fundamental idea: a simultaneous study of the climate, the oceans, the biosphere, the dynamics of the solid earth, and the biogeochemical cycles of all the major nutrients—in short, a study of the earth as an integrated whole. This study will in turn require a permanent network of satellites in orbit and another network of instruments on the ground, all feeding data into state-of-the-art computers. It will involve cooperation among earth scientists from every part of the world. And it will somehow have to be sustained for decades.

Obviously, a project of this magnitude will be neither cheap nor easy to bring off. But the enthusiasm for it seems infectious nonetheless. "[The global research program] is an idea whose time has come," says National Oceanic and Atmospheric Administration (NOAA) Administrator Anthony J. Calio. "It symbolizes the realization that a complex industrial society is vulnerable to environmental change. It symbolizes the realization that a comprehensive, global approach to understanding that change is better than ad hoc alarms over problems such as carbon dioxide buildup, ozone depletion, and acid rain. And it symbolizes the consensus that this is what we ought to be doing."

Big, international programs are hardly a new idea, of course. The global research effort is very much in the tradition of the International Geophysical Year of 1957–58, as well as such modern heirs as the Global Atmospheric Research Program. As Calio suggests, however, the past decade or so has only served to dramatize the need for a truly comprehensive program. Humans are beginning to perturb the climate and the biosphere on a planetary scale. Governments are being faced with dire warnings and controversial policy decisions. And yet the gaps in our scientific knowledge of the system are enormous. Carbon dioxide, ozone, the global climate—all are governed by processes that take place on a time scale of decades to centuries; one cannot understand them without also understanding a great deal more than we do about oceans, rain forests, ice sheets, volcanic activity, and all the interconnections among them.

The result has been what John Eddy of the University Corporation for Atmospheric Research in Boulder, Colorado, calls "a spontaneous ecumenical movement" among earth scientists. By the early 1980's, calls for a comprehensive global research program were being heard from a number of quarters, with two of the most notable being NASA's 1982 proposal for a "Global Habitability" project, and the 1983 suggestion by Herbert Friedman of the National Academy that the nations of the world cooperate on an International Geosphere-Biosphere proj-