Earthquakes: An Evacuation in China, a Warning in California

Liaoning Province in the People's Republic of China might seem to have little in common with Los Angeles County, California. But just now they are linked in the minds of the U.S. earthquake research community in ways that are both encouraging and possibly ominous.

Liaoning last year suffered a major earthquake of magnitude 7.3 that totally destroyed the town of Haicheng and damaged industrial plants; very few people were killed, although more than 1 million live near the epicenter, because the earthquake was predicted and the population evacuated—the first known instance of a major quake successfully predicted and disaster prevented or mitigated on such a scale. In the Los Angeles area, investigators with the U.S. Geological Survey have recently reported a region of crustal uplift extending 150 km along a section of the San Andreas fault that has remained quiet for 40 years and that last broke in the great 1857 earthquake. Last week, James Whitcomb of the California Institute of Technology reported seismic anomalies from the western portion of the uplift area that he believes indicate an earthquake of magnitude 5.5 to 6.5 within the next 12 months. Whether the seismic and uplift phenomena in California are associated is still an open question. But the prospect that still-developing theories of earthquake prediction might face a major test sometime soon has not lessened interest in the Chinese experience.

That experience has implications not only for the physics of earthquake prediction but also for the likelihood that major earthquakes in this country will in fact be predicted and for the host of problems that arise once a prediction has been made (see accompanying article, page 535). Indeed, as American Geophysical Union President Frank Press rather pointedly outlined in an address at the April meeting of that organization, Chinese seismologists appear to have enjoyed the active backing of their government on a scale not evident in this country. A report on the Liaoning quake prediction released by the Chinese in February, although larded with Marxist phraseology and references to Chairman Mao, makes clear that a major effort involving geological fieldwork, geodetic, gravity, and geomagnetic studies, observation of crustal deformation, and installation of temporary networks of seismic instruments had been under way in the province since 1970. By 1974, the Chinese seismologists had convinced themselves that a strong earthquake was likely within the next 2 years on the basis of increasing seismicity and an increasing rate of crustal deformation. Thousands of amateur observers, trained and assisted by the professional scientists, greatly expanded the network of seismological stations. Both the national and the provincial government took an active role in assisting the data gathering, in a disaster preparedness effort, and in a campaign of public education.

In November 1974, the rate of crustal deformation was found to be accelerating and the ground along one of the principal faults of the region was observed to be tilting rapidly—rising along one side of the fault, falling on the other. In December, agricultural communes reported unusual behavior among their animals and bubbling and level changes in their water wells. The radon content of groundwater increased. These phenomena continued to increase during January 1975, as provincial officials intensified disaster preparations, including inspecting all reservoirs, mine shafts, and industrial plants and strengthening unsafe buildings.

Around the beginning of February things came to a head. A series of small earthquakes, whose seismic characteristics indicated that they might be foreshocks, began to occur in a previously aseismic region. Other precursory signals, such as a change in direction of tilt of the surface, were observed. Level changes were observed in 70 percent of the wells being monitored, and 22 became artesian, spouting water from the ground. Cows, horses, dogs, pigs, and even snakes continued to show very unusual behavior—many of the snakes were reported to have come above ground in subzero weather and to have frozen to death. Which of these phenomena in fact precipitated a decision is still unclear to U.S. geophysicists, but mass evacuation from buildings into tent cities and other open-air shelters was ordered. Vehicles were removed from garages and grouped in special areas, and emergency squads were mobilized. And in the early evening of 4 February, a few hours after the final evacuation order was given, the quake occurred.

When a delegation visits that country later this spring, American geophysicists hope to learn more about the Chinese prediction and also about a false alarm reportedly called in late 1974. But there is little question that the Chinese did predict the quake and did save tens of thousands of lives. Press describes it as "one of the major events in the history of geophysics."

By contrast, the lack of data in southern California is disturbing to many geophysicists. The region of uplift along the San Andreas fault is not well covered with instruments. Even the extent of the uplifted area is somewhat uncertain. Robert Castle of the Geological Survey and his co-workers, who discovered the anomaly in examining past geodetic records, do not have enough data to define the bounds well to the southeast, so that it is possible that it covers an even larger area than the 12,000 km^2 originally reported. The uplift apparently began 15 years ago and has reached 0.25 m, which the investigators describe as unusually large. What is particularly unusual is the speed at which the uplift seems to have occurred—about 0.2 m at Palmdale between 1961 and 1962, near the center of the bulge—as if the ground suddenly popped. Geophysicists attempting to model the dynamics of the uplift point out that a similar process may account for the formation of the Transverse Ranges, the mountains that border the Los Angeles basin to the north, over the past few million years. The seismic consequences of whatever the uplifting process turns out to be are extremely uncertain at this point, but, as one seismologist put it, "they are unlikely to be nil." However, the speed of the uplift would appear to be inconsistent with the more gradual swelling process of dilatancy often postulated to precede earthquakes.

Whitcomb's data concern a recent phenomenon in the uplifted area. His seismic studies show a reduced velocity in both naturally occurring seismic waves and those from quarry explosions for most of 1974 and 1975, an anomaly that he interprets as a likely earthquake pre-

cursor on the basis of similar effects prior to other quakes, especially the 1971 San Fernando earthquake in the same region. He filters out the effects of small earthquakes and averages the otherwise noisy data over a large region to see the effect. The velocities returned to normal near the end of 1975. His hypothesis is based on the dilatancy model (see *Science*, 7 February 1975, p. 419) and is similar to that held by many seismologists. It is that the magnitude of an ensuing quake will be proportional to both the duration of the anomaly and the size of the area in which it is observed. Since his data do not adequately limit the size of the anomalous region to the north or the southeast, the magnitude of the quake he predicts could be still larger than the estimated 5.5 to 6.5.

More geodetic data will be obtained and Whitcomb's data closely scrutinized in coming months. The question is what other phenomena, if any, are present. As Press points out, not a single water well in California is being monitored for changes of level.—ALLEN L. HAMMOND

Diabetic Retinopathy: New Ways to Prevent Blindness

One of the more severe problems encountered by individuals who have had diabetes for a long time is degradation of vision resulting from diabetic retinopathy. This problem, which was rare 30 years ago, is becoming progressively more common as improved therapies for diabetes prolong the lives of diabetics. New results from several studies, however, suggest not only that it may be possible to retard the progression of visual impairment with currently available therapies, but also that it might be possible to prevent—or at least delay the onset of—the condition through rigorous control of diabetes.

Retinopathy is a widespread problem. It is observed in about half of those individuals who have had diabetes for 10 years, three-fourths of those who have had it for 15 years, and more than 95 percent of those who have had it for 25 years. Although not all those who have diabetic retinopathy suffer visual impairment, the disease is the leading cause of new cases of blindness in the United States among persons between the ages of 20 and 65. Some 48,000 individuals in this country are legally blind as the result of it.

Retinopathy results from the diabetes-induced deterioration of tiny blood vessels in the eye. Similar deterioration of blood vessels occurs throughout the body and causes disorders of the kidney and other organs. The cause of this deterioration is unknown. In the eye, small vessels become leaky and occluded and, occasionally, new vessels form on the retina. In the more severe form of the disease, known as proliferative retinopathy, new blood vessels grow on the surface of the retina and protrude into the vitreous, the normally clear, jellylike fluid in the center of the eye. Eventually, these vessels rupture and hemorrhage into the vitreous. And finally, fibrous scar tissue forms in association with the new vessels. This tissue may pull on the retina and detach it from the back of the eye. Proliferative retinopathy occurs in only about 3 to 4 percent of diabetics, but even so this comes to about 300,000 people in the United States who are susceptible to blindness from it.

Diabetic retinopathy is difficult to study in the laboratory because there are very few animal models for it, and these are not entirely satisfactory. One model of proliferative retinopathy similar to that caused by diabetes has been developed by Arnall Patz and Chung-Ho Chen of the Johns Hopkins School of Medicine. They observed that growth of blood vessels (vascularization) in the retina occurs naturally in puppies during their first 4 weeks after birth. If the puppies are exposed to an atmosphere of 85 percent oxygen for a 4-day period during this time, the peripheral vessels in the eye are destroyed, and new vessel formation begins at the border of the obliterated vessels after the dogs are removed to air.

Chen has found that the total amount of protein dissolved in the vitreous is closely related to the rate of vascularization in normal development, with the protein concentration declining to barely detectable amounts as vascularization nears completion. The new vascularization after exposure to oxygen is preceded by a sharp increase in the concentration of protein in the vitreous. Patz and Chen thus speculate that one or more of these proteins may be responsible for the new growth.

This speculation is supported by other experiments in which Patz, and his colleagues at Johns Hopkins, Daniel Finklestein and Steven Brem, implanted small malignant tumors in the vitreous. Such tumors have been shown by F. Judah Folkman and his associates at the Harvard Medical School to release a protein, named tumor angiogenesis factor or TAF, that stimulates the growth of new blood vessels toward the tumor. TAF may be similar to the protein observed in the vitreous of newborn and oxygen-treated puppies. When introduced into the eye, TAF produces retinal vessel proliferation.

The tumors thus provide another model for proliferative retinopathy. They also make it possible to study agents that may inhibit the process. Folkman has found, for example, that a substance extracted from cartilage inhibits TAF. Patz and his associates speculate that this or a similar inhibitor might block retinal vascularization. It might thus be possible, sometime in the future, to find ways to stimulate the activity of such a natural inhibitor or to develop synthetic agents that could block the growth of new vessels in the eye.

Another animal model has been developed by Albert E. Renold and his associates at the Institute of Clinical Biochemistry of the University of Geneva. They render a special strain of rats diabetic with streptozotocin, an antibiotic that destroys insulin-secreting cells in the pancreas. They then observe that most of the rats that survive for as long as 9 months without insulin therapy exhibit many characteristics of retinopathy. They further find that they can isolate the retina and, by studying it under a microscope, quantitate many of the physical changes and correlate them with biochemical changes.

One of their major findings is a marked decrease in the number of mural cells that line the exterior of blood vessels. They observe a strong correlation between the extent of loss of mural cells and the concentrations of insulin and glucose in the blood and the volume of urine. This loss of mural cells could produce structural weakening of small blood vessels and lead to their rupture. Such a loss of cells was observed in only about half of a group of rats that were diabetic only 5 months, indicating that the loss is time-related.