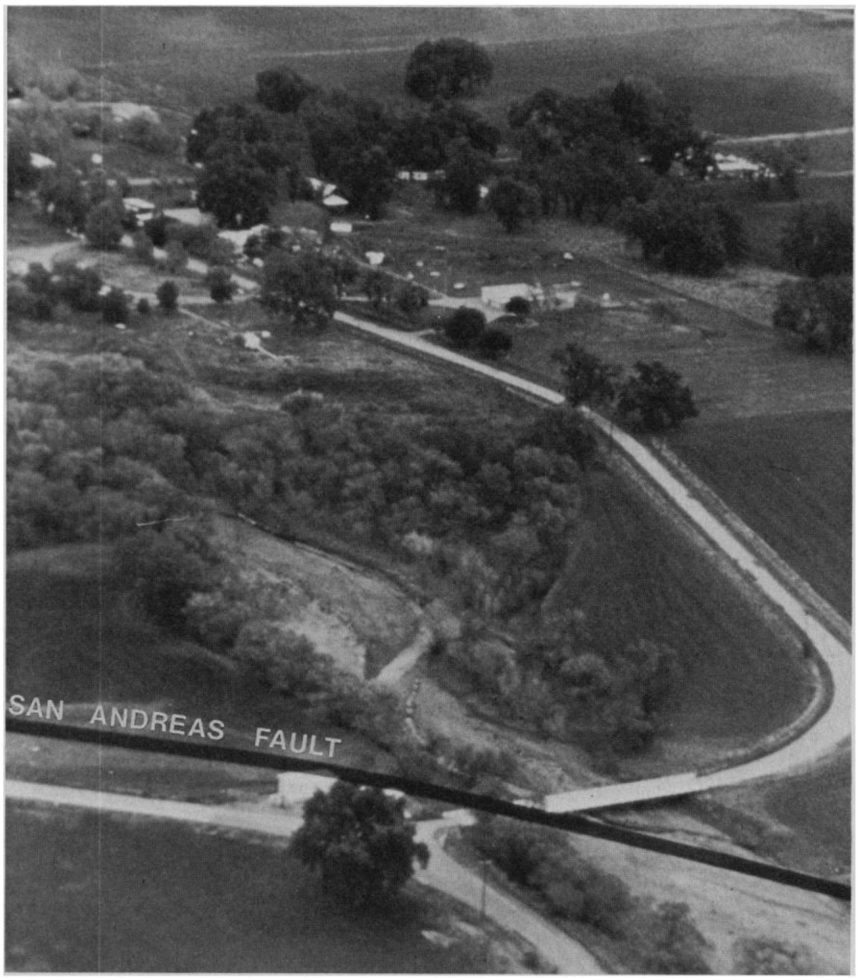
Parkfield Earthquake Looks to Be on Schedule

The only formally endorsed prediction of an earthquake in the United States appears to be holding up well. The magnitude 5.6 Parkfield earthquake, expected to strike a section of the San Andreas in sparsely populated central California in January 1988, give or take 5 years, would appear to be on schedule despite a jolt to the Parkfield area from the nearby Coalinga earthquake.

Catherine Poley and Allan Lindh of the U.S. Geological Survey in Menlo Park re-



W. Bakun

Parkfield, California, a small town threatened by a large earthquake.

ported at the American Geophysical Union (AGU) annual fall meeting in December that activity at Parkfield has resumed after a quiescence apparently induced by the May 1983 Coalinga earthquake. Shortly after the shock at Coalinga, seismic activity deeper than 6.5 kilometers ceased beneath Middle Mountain, the spot on the San Andreas where the most recent Parkfield earthquake in 1966 began its rupture. At the same time, the creeping of opposite sides of the fault past each other stopped at Middle Mountain and elsewhere. Then both the deep seismicity and the creep at Middle Mountain resumed in August 1984. Within recent weeks, creep elsewhere along the Parkfield section of the San Andreas has apparently resumed, accompanied by a small flurry of seismic activity.

Another, more warily regarded, sign that stress continues to be added to the Parkfield fault section, leading toward its eventual failure, was a small, magnitude 3 earthquake that struck in May of this year close by the point on the fault where the 1966 rupture began. Lindh had noticed that similar small events had clustered at the same spot, striking every 39 to 41 months since 1971. The April 1984 event "predicted" by this clock-like sequence never appeared, but this May's earthquake, the largest beneath Middle Mountain since 1982, fell at the right place. If one is willing to believe that the Coalinga earthquake simply slowed stress accumulation at Parkfield by about 14 months, as indicated by the quiescence, then this magnitude 3 earthquake could be the expected one. The next event in the sequence would come in August 1988, says Lindh. Conceivably, it could then trigger the main shock awaited by seismologists.

A far more substantial indicator of the imminence of the next Parkfield earthquake comes from geodetic surveys. Ruth Harris and Paul Segall of the USGS in Menlo Park reported that the strain that will be stored by 1988 on the fault will at least equal the strain released during the 1966 rupture. Because the three most recent Parkfield earthquakes were nearly identical in size, the next one will presumably occur when the same amount of strain has been stored. The coincidence of this prediction, based on changes in precisely measured distances across the fault, and the original prediction, based on the regular recurrence of similar earthquakes, points strongly toward 1988 as the most likely time for the next Parkfield earthquake. ■

A Search for Another San Andreas

The North American and Pacific crustal plates slide by each other along the San Andreas, generating California's most famous earthquakes. But the boundary between the two plates is far less neat and clean than the thin line of the San Andreas might imply. Space-based methods of measuring plate motion are now confirming that only 60 percent of the relative motion between the two plates occurs on the San Andreas. The rest of the motion, and possibly some unexpected major earthquakes, must occur away from the San Andreas. The space-based methods are also beginning to hint where that motion may occur.

At the AGU meeting, several groups reported that motion on faults other than the San Andreas has set adrift at least one part of California; it does not seem to be firmly anchored to either the Pacific or North American plates. Thomas Clark and James Ryan of the Goddard Space Flight Center in Greenbelt, Maryland, and David Gordon of Science Applications Research in nearby Lanham used very long baseline interferometry (VLBI), a method involving the simultaneous recording of radio signals from deep-space quasars, to measure distances of hundreds or thousands of kilometers with precisions of a few centimeters. They reported that the distance between Quincy in northeast California and Monument Peak on the other side of the San Andreas near the Mexican border has been increasing about 34 millimeters per year during the past few years.

Motion of 34 millimeters per year clearly places Monument Peak somewhere off the North American plate, but it is not firmly on the Pacific plate either. Clark noted that Monument Peak is also moving at about 39 millimeters per year with respect to Westford, Massachusetts. That is a site shown to be stable with respect to the rest of North America save the far West, so it is Monument Peak and not Quincy that is drifting independently of North America, Clark says. Monument Peak does seem to be moving about as fast as the immediate western side of the San Andreas, as measured by conventional surveys along the fault and by geologic measures of fault slip during earthquakes. But Monument Peak's speed falls short of the 56 millimeters per year generally accepted for the Pacific plate. Bernard Minster of Science Horizons in Encinitas and Thomas Jordan of the Massachusetts Institute of Technology have estimated that rate from geologic indicators, such as magnetic lineations on the sea floor.

Thus Monument Peak must be on a small crustal block or sliver caught between the North American plate and the faster moving Pacific plate. At least one VLBI site, however, may be firmly attached to the Pacific plate. Clark found that the Vandenburg site, which juts into the Pacific in south-central California, is moving northwestward parallel to the San Andreas at the 60 millimeters per year expected of the Pacific plate.

The next step would be to pin down exactly where, besides on the San Andreas, the plate motion is occurring. Suggestions have ranged from the Basin and Range province of Utah to faults that slice through Los Angeles. Minster and Jordan's preferred site for central California is an offshore fault or faults. When they constrain the crustal deformation west of the San Andreas caused by plate motion, using geologically determined motions of the stable plates and the Basin and Range province, they find that part of the remaining relative motion would lead to compression and crumpling of the crust across the fault. But part of the motion would occur as San Andreas–like slip on a fault or faults parallel to the San Andreas.

A likely candidate would be the offshore Hosgri fault, they say, which runs by the controversial Diablo Canyon nuclear power plant and becomes untraceable to the south toward the new shuttle-launching facilities at Vandenburg Air Force Base. The 10 to 20 millimeters per year of relative motion predicted by their model, if all of it were accommodated on the Hosgri, would make that fault more active than the San Jacinto fault of southern California. The San Jacinto, a branch of the San Andreas, has generated more destructive earthquakes in the history of California than any other fault.

Herbert Frey of the Goddard Space Flight Center announced that the Crustal Dynamics Project, under which plate motion measurements are being made, will for a time include more frequent measurements of fewer baselines in order to affirm recent results and to check a possible slowing of plate motion recorded in the past few years by the satellite laser–ranging technique. ■

Long Valley Is Quiet but Still Bulging

Long Valley caldera, the huge volcanic scar just to the east of Yosemite National Park, has been quieting down ever since four magnitude 6 earthquakes rocked the caldera during 3 days in May 1980. The ominous bulging of the valley floor has not gone away, however, suggesting that the vigil at Long Valley could be a long one.

David Hill and Robert Cockerham of the U.S. Geological Survey in Menlo Park reported at the AGU meeting that the quieting down of Long Valley continues. Thirteen earthquakes larger than magnitude 5 have struck the area since October 1978, but the most recent occurred over a year ago in November 1984. Within the caldera, the level of seismicity has dropped from two to three events per day greater than magnitude 1 in most of 1984 to less than 0.5 per day in 1985. John Langbein and his colleagues at the USGS in Menlo Park reported that the growing quiescence extends to the deformation of the southern caldera edge, where a swarm of microearthquakes had marked a possible finger of upward-moving magma. Whatever caused this near-surface disturbance, it seems to have died out for the time being.

Deeper beneath the caldera, things are not so quiet, according to surveys conducted by James Savage of the USGS in Menlo Park. Judging by the bulging of the valley floor detected in surveys of height and distance changes, magma has continued to fill the chamber 10 to 12 kilometers below at a roughly steady rate from 1982 to 1985. The maximum uplift during that time was about 35 millimeters each year while seismic activity tapered off from year to year. If there has been any change in the bulging, it has been a shift of the uplift center toward the western edge of the caldera and the Mono and Inyo crater chains, where volcanic eruptions occurred as recently as 600 years ago.

The steady inflow of deep magma, which is either the direct cause of the seismicity or a product of the crustal stresses that drive all the activity, would imply that more earthquakes or even an eruption could strike Long Valley despite the current quiescence. The timing of any such activity remains problematic. Yellowstone caldera has risen an average of 15 to 20 millimeters per year since 1923 with only the occasional moderate earthquake or seismic swarm. ■

How to Stir Up a Deep-Sea Storm

Oceanographers long ago discarded the view of the ocean abyss as dead and stagnant, but the swift-flowing currents found in recent years along some parts of the bottom still surprised and mystified them. To help clear up the mystery, physical oceanographers are proposing new twists on old means of driving currents so far from wind-driven currents at the surface.

At the AGU meeting, Georges Weatherly of Florida State University described how one deep current, after traveling 12,000 kilometers from its source, may turn around and sweep along the edge of the abyssal plain south of Nova Scotia. It has long been known that Antarctic Bottom Water sinks from the surface near Antarctica and flows northward along the bottom into the western North Atlantic.

Weatherly is suggesting that before completely mixing with North Atlantic water and dispersing, some of this flow curves to the west due to Earth's eastward rotation and hugs the lower edge of the continental rise at the edge of the abyssal plain. That current, along with the lower reaches of occasional intense eddies pinched off the nearby Gulf Stream, could account for the muddy waters kicked up from the 5000-meter bottom south of Nova Scotia, Weatherly says. Hydrographic surveys suggest that this deep undercurrent extends as far south as the Bahamas, he notes.

Nelson Hogg of Woods Hole Oceanographic Institution offers a more local explanation—a gyre caught between the Grand Banks off Newfoundland to the north and the New England seamount chain to the south. This would provide a background flow on which deep eddies induced by the Gulf Stream, by means that remain uncertain, could be superimposed to produce the storms of sediment-laden water. Either way, some of the ruckus in the deep sea must be ultimately conveyed from the surface, something to which oceanographers had given little thought. ■