California's Ups and Downs

Comparisons of three kinds of observations taken at three sites in southern California show that the earth there rises and subsides in a gradual cycle. But residents of the area, for whom the possibility of earthquakes is commonplace, need not hold their breath: the slight uplift and subsidence, itself something akin to breathing, is not associated with earthquakes in the seismically active zone.

The correlation of changes in gravity, strain and elevation in southern California is described in the March 11 SCIENCE by Robert C. Jachens, Wayne Thatcher, Carter W. Roberts and Ross S. Stein, all of the U.S. Geological Survey in Menlo Park, Calif. The three kinds of observations, each useful in detecting deformation of the earth's crust, were made repeatedly from 1977 through 1982 at Tejon Pass, Palmdale and Cajon Pass, all along the San Andreas fault.

"Somewhat surprisingly, the three time histories from these three sets of measurements at three different locations all seemed to correlate fairly well," Jachens says. When the elevation went up, the gravity decreased and the horizontal strain showed that the size of the study area was reduced, as would be expected if the earth were being squeezed. Then, in what may be a continuous pattern, the swelling subsided and gravity and surface area both increased. Elevation changes were measured by leveling instruments, strain by a laser device that measures the time it takes a beam of light to travel back and forth between two points, and gravity by instruments called gravimeters that can detect changes in the gravity of a given point. When a point on the earth is raised even a few centimeters, its gravity decreases because it is that much farther from the earth's center. Then, when the earth subsides, gravity increases as the surface moves slightly closer to the core.

The measurements reflect up and down movement in cycles of one to two years, and a maximum uplift of about 10 centimeters per year. After six years of observations, gravity measurements at the three sites, and at 10 others throughout the Mojave desert and the front ranges, all were back to their 1976 levels. Despite questions about the precision of the measurement systems, "the rather good agreement among them suggests that the observed changes reflect true crustal deformation," the authors write.

Explaining the findings is more difficult. The scientists do not know what causes the specific swellings (though broad changes related to movements of the crustal plate are known and expected) or why they happen without the earthquakes that might occur along the active fault.

The authors suggest two possible explanations, but they say neither is satisfactory. One cause could be that a horizontal plate is being squeezed, but in order to account for the actual measurements, the plate would need to be 200 kilometers to 300 km thick. Most researchers believe that the crust under southern California is only tens of kilometers thick. Another possibility is that the data reflect slip along a buried, horizontal fault. However, such a fault would not explain the cyclic pattern of deformation because it would require slip in one direction, and later in the opposite direction.

The findings are of special interest because controversy still surrounds the so-called Palmdale bulge. The aseismic swelling is thought to have developed in the early 1960s and subsided in the late 1970s over a huge expanse of southern California (SN: 2/3/79, p. 74). Some scientists, such as Sandford R. Holdahl of the National Geodetic Survey, believe that the bulge never occurred at all. Instead, Holdahl says, the bulge was an artifact of refraction errors (bending of the line of sight) and of an instrument used in the 1970s that tends to respond to the earth's magnetic field, leading to faulty observations.

The recent findings may support the existence of the Palmdale uplift. Jachens says that the data argue "strongly that there are aseismic deformations [deformation of the earth, but no earthquakes] going on along this plate boundary, and that they are not really that unusual." James Savage of USGS explains that if changes 10 cm or greater can occur in a year or so, then it is not unlikely that a 30 cm uplift, such as that reported for Palmdale, could take place. While he believes that the Palmdale bulge existed, "the question is still open," he says. "The first thing to do is get more data, and see if we can substantiate the trend."

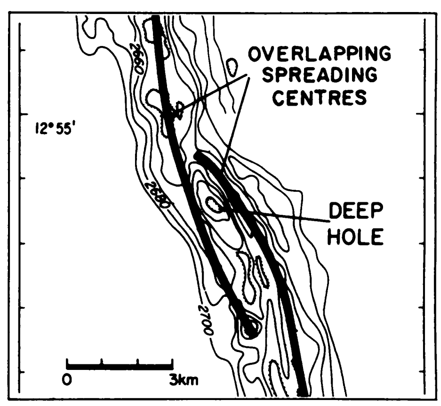
Though the breathlike movement does not appear to heighten the possibility of earthquakes in southern California, it is interesting to earthquake predictors because changes in strain and other signs of deformation are thought to be warnings that an earthquake might occur. Aseismic uplift and subsidence might make a true earthquake precursor more difficult to recognize, Savage says. "If things like this are going on continually," he says, "then the noise in which we have to make our observations is very high." —*C. Simon*

Seafloor spreading ridges that overlap

Mid-ocean ridges or spreading centers are constantly generating new seafloor as molten fluid from the underlying mantle rises up along these features and spreads outward. Segments of the ridges are usually offset from each other by "transform faults" perpendicular to the ridges. Now, Ken C. Macdonald of the University of California at Santa Barbara and Paul J. Fox of the University of Rhode Island in Kingston may have evidence that the spreading ridge segments can overlap for short distances without transform faults forming. The features may be common in seafloor created at fast spreading ridges, the researchers say. They describe the overlapping spreading centers (OSCs) in the March 3 NATURE.

Using sophisticated sonar systems on a research cruise during the summer of 1982, they observed eight areas of the East Pacific Rise where two ridge segments, marked by lines of young volcanoes, approach and curve toward each other (see figure). In the largest system, the segments overlap by 25 to 35 kilometers and enclose a basin more than 500 meters deep.

Because the lengths of ridge overlap are small, and because the East Pacific Rise is a young, hot, fast spreading center, they suggest that the overlapping ridges form when the crust is "too thin and weak" for straight ridges and transform faults to form. Detailed surveys of the older, slower mid-Atlantic ridge, they say, have not revealed any overlapping ridges.



Macdonald, Fox/© Nature

An example of a small-offset overlapping spreading center. Contours indicate depth to the ocean bottom.

The researchers were able to recreate in a laboratory ridge configurations much like those along the East Pacific Rise by cutting parallel slits in paraffin plates floating on molten wax, and allowing the slits to grow in length by causing currents in the wax with paddles. They note that both overlapping ridges and "propagating rifts"—ridges whose trends and spreading directions are changing — form at fast spreading centers. The overlapping ridges, they say, may be "nucleation points" where the large-scale propagating rifts first begin to grow (SN: 6/19/82, p. 408). —*A. Chen*