Microquakes — A Tool For Understanding Destructive Earthquakes?

Very small shocks may help determine the strain rate along a fault

Portable seismometers originally developed at Caltech to land on the moon to detect possible moonquakes are now being used closer to home to measure extremely small earthquakes. These "microquakes" are too weak to be detected on ordinary seismometers; their magnitudes are about one-millionth that of the smallest destructive earthquakes.

James Brune, associate professor of geophysics, has been measuring microquakes as part of a major research program being conducted by Caltech geologists and geophysicists to instrument and study sections of the San Andreas fault. Associated with him on this project are Clarence Allen, professor of geology and geophysics and interim director of the Caltech Seismological Laboratory; and Frank Press, former director of the laboratory and now chairman of the department of geology and geophysics at MIT.

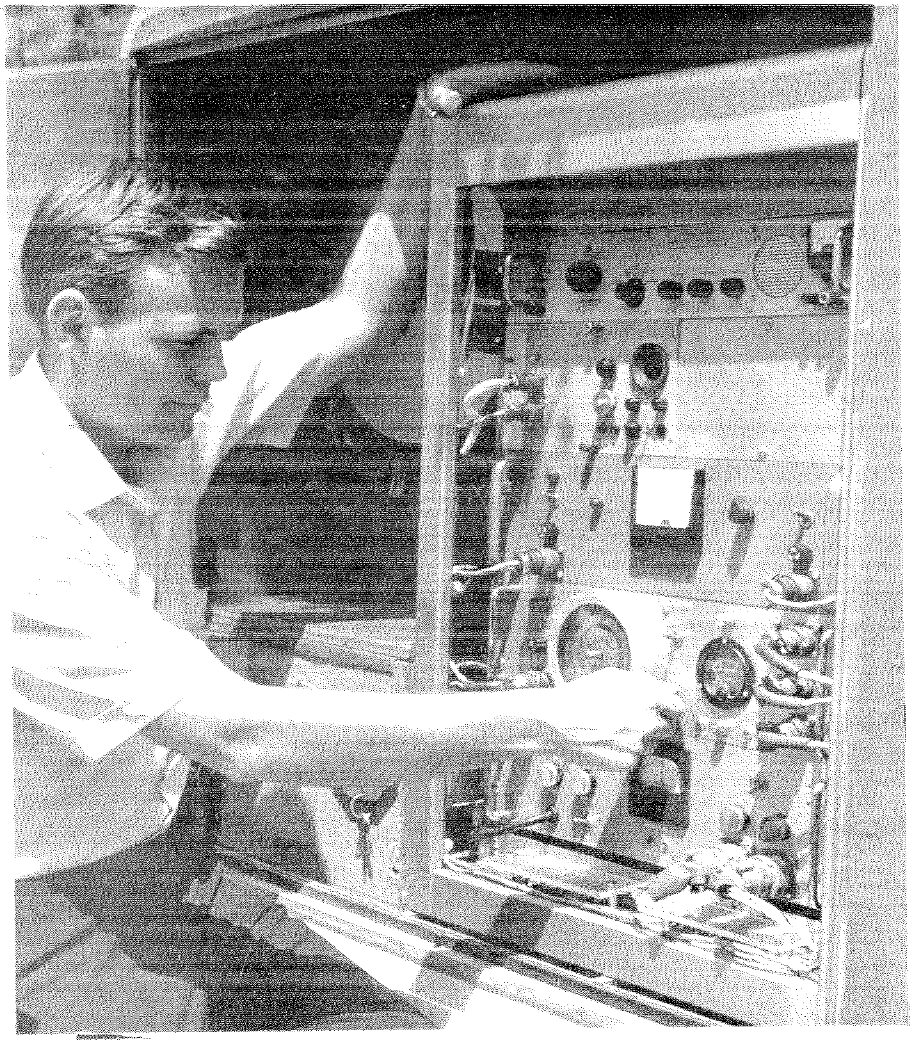
Microquakes may provide clues to the understanding of large earthquakes, and possibly even to their prediction. They will certainly reveal more about the great forces that move large land masses. Microquakes are probably caused by small movements along underground cracks near a major fault; most of them occur at depths of less than ten miles. Thus, while microquakes are concentrated near large active faults, they usually do not represent movement along the fault itself. However, on the San Andreas they do appear to be associated with "creep" along parts of the fault. The creep, in turn, is a reflection of the regional stress that is always present and which keeps the land on the west of the fault moving north, relative to the other side, at a rate of about two inches per year.

If seismologists are ever going to be able to predict earthquakes, they must first understand the relationship between stress accumulating at various sections of a fault and relief of that stress through creep and slippage. It is not now clear what role microquakes play in this give and take. However, it is unlikely that they actually can relieve any significant amount of stress. Rather, they may serve as an indication of the presence, absence, or change in stress patterns.

The San Andreas is being monitored for microquakes at selected sites between Hollister and Brawley, a distance of some 400 miles. Activity, which seems to be concentrated only in certain areas, occurs near Hollister and San Bernardino, where creeping has been observed. Unexpectedly, the 175-mile stretch between Cholame (on the fault east of Paso Robles) and Wrightwood (in the San Gabriel Mountains) is relatively quiet. Such silence along some sections of the fault could mean that the fault is "locked" so that stress is building up, or it could mean the reverse—that no strain exists.

Microquakes tend to occur in bursts and are very irregular in frequency at any one location. More than 125 a day were recorded at the south end of the Salton Sea near Brawley. On the other hand, at Lake Hughes, 40 miles north of Los Angeles, an average of only one every ten days was recorded over a period of about a year. This is contrary to what might have been expected because the Lake Hughes area is directly on the fault. The frequency of microquakes recorded there corresponds to that found in such stable areas as New Jersey.

Microquakes have been recorded on other active faults in California and Nevada, in addition to the San Andreas. Flurries of microquakes have been detected along the Elsinore and San Jacinto faults



James Brune, associate professor of geophysics, uses trailer-mounted equipment to record the output of a portable seismometer located on the ground not far away.

in southern California, for example. In general, any given 30-mile diameter area in southern California will have an average of one to ten microquakes a day. Of course the actual number recorded depends on the sensitivity of the instrument and the background noise in the ground. If this noise could be reduced, even more microquakes could be recorded.

The equipment is mounted on small, two-wheeled trailers that can be towed to almost any desired location and set up quickly. The seismometers are put into the ground and linked by cable to recorders in the trailers. The equipment was built with the support of the Advanced Research Projects Agency's Project Vela. Francis Lehner, special projects engineer at Caltech's Seismological Laboratory, has supervised the development of the equipment. The over-all San Andreas research program is being sponsored by the National Science Foundation.

For maximum precision, the instruments can be set up in the form of an array of five, with one placed at each corner of a square about ten miles on a side, and with one in the middle. With the array it is possible to make an accurate determination of the origin of a microquake.

It may eventually be possible to obtain a quick seismic picture of an area by using microquakes. Perhaps there is a correlation between them and other phenomena, such as earth tides and temperature changes. Ultimately, it is hoped that microquakes will help seismologists understand the mechanisms of large earthquakes.

Seismometers for detecting microquakes along the San Andreas fault were originally designed to be landed on the moon to detect possible moonquakes.