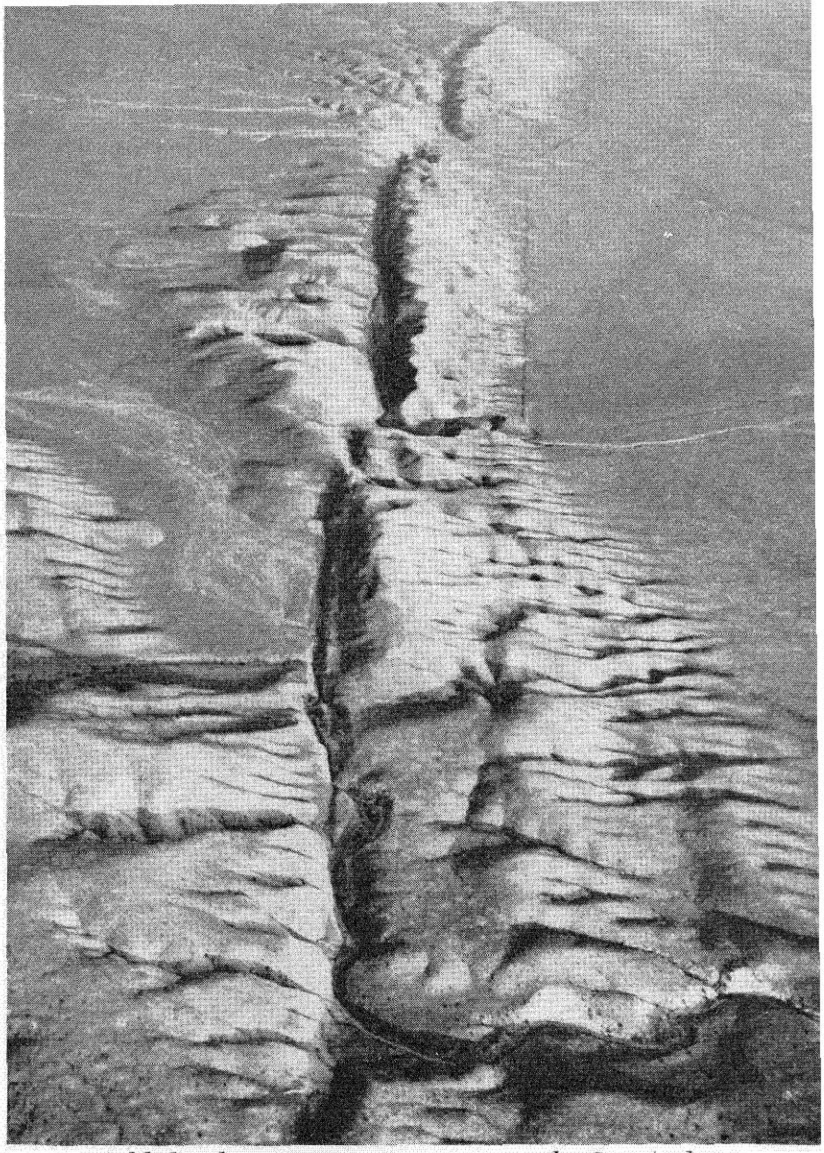
EARTHQUAKE PATTERNS

New conclusions based on a study of Caltech records



A likely place for seismic activity — the San Andreas fault trace in the Carrizo Plains area, west of Taft, in California's Central Coast Range.

A 29-year history of southern California earthquakes has been collected, studied, processed in a computer, and analyzed by a group of Caltech seismologists, who have drawn some new guidelines for evaluating earthquakes and their hazards. The conclusions reached by the team are of particular interest to southern Californians, and may affect some commonly held beliefs about seismic activity. The work was done by Dr. Clarence Allen, interim director of Caltech's Seismological Laboratory; Dr. Charles Richter, professor of seismology; John Nordquist, senior research assistant in seismology; and Dr. Pierre St. Amand, a Caltech graduate who is now head of the Earth and Planetary Sciences Division of the Naval Ordnance Test Station in China Lake, California.

Records from more than 10,000 earthquakes, dating back to the beginning of formal publication of records at the Caltech Seismological Laboratory (1934), were the primary source of data for the study, which was undertaken to gain a better understanding of current tectonic processes in an area of present-day mountain building. The general method of study was comparison of seismic activity with geologic structure — both of which are relatively well known in the southern California region. The region of study was roughly bounded by Mono Lake, California; Ensenada, Mexico; Yuma, Arizona; and the offshore Channel Islands.

Among the conclusions that resulted from this survey and analysis:

Faults that have been most active in the recent geological past (within the last million years) are the most likely candidates for future activity.

This is suggested by the over-all historical record, as well as the abundant geologic evidence for recurrent displacements along such major fault systems as the San Andreas. Also included are the Salton Sea trough; the Agua Blanca-San Miguel fault region in Baja California; most of the Santa Ynez, Santa Monica, San Gabriel, and San Bernardino mountains; the central Mojave Desert; and most of Owens Valley.

Gradual slippage along faults may be a more important factor in relieving strain than was previously thought.

It has been demonstrated that land masses on either side of portions of the San Andreas fault move in opposite directions, building up strain along the fault until the friction of rock against rock is finally overcome, causing an earthquake. While this is still believed to occur, measurements have shown that in some areas there is a corresponding movement along the fault plane — a gradual slipping that produces no shock, but which relieves part of the regional strain. Evidence of such slippage is found in Hollister, where the concrete floor of a winery built across the fault is cracked, with one side moving about an inch a year relative to the other side. However, the concrete lining of the Elizabeth Lake water tunnel of the Owens Valley aqueduct passes right through the fault and has not cracked at the fault in the 52 years it has been there, so it must be concluded that this slippage does not occur on all sections of the fault, if on very many at all.

Occurrence of small earthquakes is not a valid prediction of large earthquakes, at least on a time scale comparable to the one used in the study.

Smaller shocks may actually relieve strain as it builds up, making a large earthquake less likely. This may be the case in the Imperial Valley, which has high seismic activity, but no record of recent great earthquakes.

Temporary quiescence in a seismically active zone may be more a cause for apprehension than for comfort.

Sudden, violent earthquakes in quiet areas have provided illustrations of this several times in the last few years. The great 1960 Chilean earthquake occurred in an area that had been identified as one of low seismicity back to 1904 (the advent of earthquake records for the area), but in a region that had great earthquakes in 1575 and 1835. Before the earthquake, some residents had never felt as much as a slight tremor. Similar examples were 1964 earthquakes in Niigata, Japan, and Prince William Sound, Alaska, and a 1962 earthquake in Iran. While that portion of the San Andreas fault zone northwest of San Bernardino is one of the most seismically quiescent in southern California (with the last major earthquake along it in 1857 at Fort Tejon), it is possible that some strain release does occur through gradual slippage. The current intensive study of the San Andreas fault being conducted by a team of Caltech geologists and geophysicists (*E&S — November 1964*) should provide new data on such strain release. Other quiet areas with active histories include the central Owens Valley and the Banning-Mission Creek fault zone between the Imperial and Coachella Valleys along the east side of the Salton Sea.

Proximity to active faults is by no means the only criterion of seismic hazard.

No part of southern California is very far removed from one or more faults that have a demonstrable history of recent displacements. Another significant factor is related to ground conditions, which may play a greater role than location in determining hazard (within certain limits). The 1964 Alaskan earthquake demonstrated this point; ground seemed to lose its strength and fail at great distances from the center of the shock under prolonged shaking, causing extensive damage. In addition, it has been suggested that shaking during a great earthquake may be more intense at some distance from a fault than very close to it.

Aftershocks may cause more damage than the initial shock.

The shallow aftershocks are distributed over a much larger area than is generally realized, and may do more damage in a local area than the main shock itself. In the 1952 Kern County earthquake, an aftershock caused more damage in Bakersfield than did the main shock. Following the Chilean earthquake in 1964, an aftershock of magnitude 7.1 occurred more than 500 miles from the epicenter of the initial shock, and presumably not on the same fault. (For comparison, the 1933 Long Beach earthquake had a magnitude of 6.3.)

Geologic history covers time periods so much longer than man's actual observations of the earth that the data used in this or any similar study could be anomalous, which is why any conclusions drawn for particular areas must be accepted with the numerous constraints imposed by a limited frame of reference. In this vein, the investigators pointed out four areas (the Oceanside-San Diego region, the easternmost and westernmost portions of the Mojave desert, and the central San Joaquin Valley) in southern California that are probably truly stable, because they have a combination of (1) low earthquake activity during the period of study and (2) relative lack of faults showing movements during the last million years.

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