STUDYING THE SAN ANDREAS FAULT

An eight-man team of geophysicists, seismologists, and geologists from Caltech undertakes an intensive two-year investigation of the geological structure that is potentially the most dangerous on this continent

The San Andreas fault, a gigantic fracture zone some three to six miles wide which extends three-quarters the length of California, is the most potentially dangerous geological structure in North America. Caltech has now started an exhaustive study of this notorious fault by an eight-man team of geophysicists, seismologists, and geologists.

The ultimate objective of this study is to understand better the nature, mechanics, past history, and present condition of this fault, in order to evaluate its role in the geological evolution of the Pacific Borderland, to predict its future behavior, and to gain an insight into processes deep within the earth.

The San Andreas fault extends more than 650 miles southwest from California's Mendocino coast through the Coast Ranges and along the north edge of southern California's San Gabriel Mountains, eventually breaking into several branches that extend into the Gulf of California.

The land mass west of the San Andreas is continuously moving northward at a rate of two inches a year – more than 16 feet in a century – in relation to the mass east of it. This lateral movement may have totaled 350 miles over many millions of years.

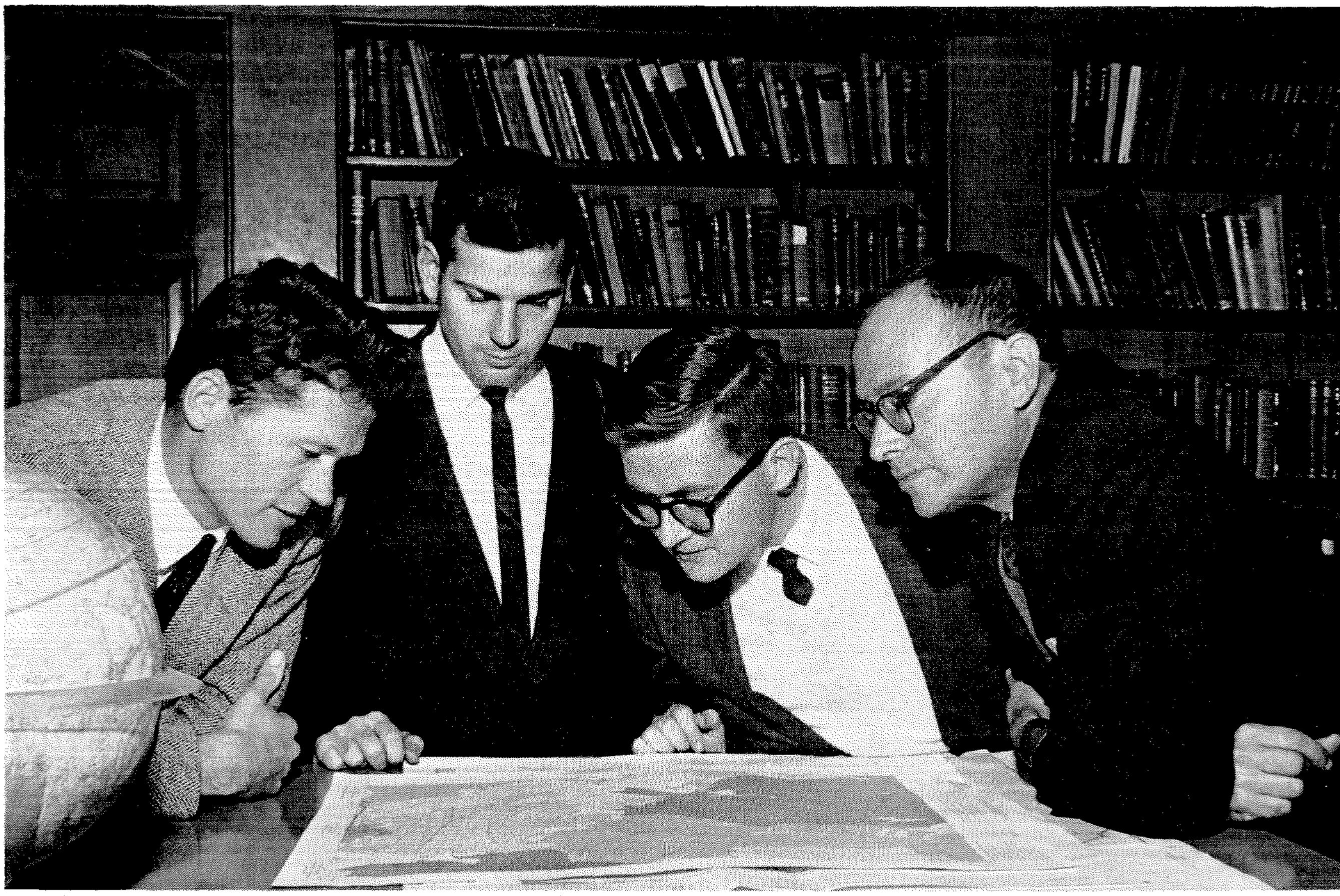
With two land masses moving in opposite directions, something has to give where they join. It does so along the San Andreas – not continuously, but infrequently, in sudden jerks. The distortion or strain builds up along the fault to a point where it exceeds the strength of the rocks and they break. The rocks suddenly slip many feet horizontally to relieve the strain and an earthquake results, releasing enormous amounts of energy.

"The San Andreas," says Robert P. Sharp, chairman of the Division of Geological Sciences, "can be thought of as a window through the earth's crust by means of which we can see far into the interior. True, it is a narrow, cracked, dirty, cobwebby window, but with skill, patience, and modern techniques and instruments we will be able to see more deeply and clearly into the earth than ever before."

Researchers comprising the team that is making this study are Clarence Allen, professor of geology and geophysics; Don L. Anderson, associate professor of geophysics; Barclay Kamb, professor of geology and geophysics; Leon Knopoff, research associate in geophysics at Caltech, and professor of geophysics at UCLA; Robert L. Kovach, assistant professor of planetary science; Frank Press, director of the Caltech Seismological Laboratory, and professor of geophysics; Stewart W. Smith, associate professor of geophysics; and Gerald J. Wasserburg, professor of geology and geophysics.

Drs. Kamb and Smith plan to measure the actual distortion of the rocks in and adjacent to the fault, with strain seismometers employing interferometry and capable of recording movements of one-millionth of an inch. Each of Dr. Smith's measuring stations will record strain over comparatively small areas, while each of Dr. Kamb's will cover more than half a mile.

Dr. Smith proposes the installation of an array of a dozen stations extending two to four miles across the fracture zone, possibly in the Lake Hughes area, some 45 miles north of Los Angeles. He has developed an automatic strain-measuring instrument. It consists essentially of three 10-foot quartz rods placed in a tripod shape below ground, the lower ends anchored to rock and their upper



Barclay Kamb, professor of geology and geophysics; Stewart W. Smith and Don L. Anderson, associate professors of geophysics; and Frank Press, professor of geophysics, and director of the Caltech Seismological Laboratory.

ends linked to an interferometer whose interference patterns are recorded by a camera. He plans to install the first station by the first of the year and expects that in a few months a strain pattern will appear.

Dr. Kamb will attempt to measure ground distortion with a triangle of mirrors anchored to rock and located some half a mile apart, the mirrors reflecting light into an interferometer. Any movement of one mirror in relation to the others will be recorded. If these measurements are possible, then detailed records can be made of progressive distortion. Several such installations could map the strain pattern for ten miles each side of the fault. Possible sites for the stations include Table Mountain near Wrightwood, Hollister, Anza, Carrizo Plain west of Taft, and Hughes Lake.

"We also hope to measure the strain at depth," says Dr. Kamb, "and to compare this with strains computed from the surface measurements. We want to know if the strain build-up is continuous or jerky and how far it extends each side of the fault."

While it has generally been believed that the fault extends at least through the earth's crust to the mantle, some 20 to 30 miles deep, certain calculations suggest that it may extend down only as far as five miles. The rocks below that depth may be sufficiently plastic to flow.

The depth of the fracture will be measured by placing seismometers at strategic locations to record the passage of waves – generated by earthquakes arising from other faults (not necessarily the San Andreas), and by explosions – through and below the fault. Records of such waves passing through the fracture zone will be used by Drs. Press and Knopoff and others to "x-ray" the composition of the fault zone. Does it consist of ground-up rock or rock whose temperature was raised to or near the melting point during large fault movements in the past?

With an array of eight portable, sensitive seismological stations built into trailers, Dr. Press will gather information relating to these questions and also will attempt to determine whether very small earthquakes—too small to be detected with standard instruments—occur along the fault. If such temblors occur, they could relieve at least part of the accumulating strain. The site for the initial seismic recordings will be in the vicinity of Lake Hughes.

Drs. Wasserburg, Kovach, and Knopoff will make heat studies designed to show if the energy released

Clarence Allen (right), professor of geology and geophysics, and an authority on the San Andreas fault; and Gerald J. Wasserburg, professor of geology and geophysics, who will take heat measurements in the fault zone.

by the fault adds significantly to the heat flow from the earth's interior. Several holes will be bored in profiles across the San Andreas zone to depths of perhaps 1,500 feet.

Heat measurements will be made at various depths to learn if the fault zone is hotter than areas on each side. Fault ruptures may heat the underground rocks to higher temperatures than are characteristically found.

Dr. Anderson will measure changes in the elastic properties of rocks caused by strain increases. This information could be very useful in anticipating earthquakes. It seems likely that the compressing and stretching of rock formations adjacent to a fault would be accelerated before an earthquake is triggered.

Dr. Anderson will deploy six to nine seismometers in a grid perhaps a mile square on some active area of the San Andreas. Explosions touched off periodically at a fixed location on one side of the fault will generate waves that will radiate through the fracture region. The waves travel faster through compressed rock and slower through the same kind of rock when it is stretched. By periodically determining the velocities of the waves through these rocks it may be possible to measure changes in their elastic properties.

Other kinds of instruments will be used in the extensive study, including gravimeters to show the densities of subsurface areas in and near the fault. If rock is crushed its density may be changed.

Dr. Allen, an authority on the fault, is working with the other investigators as a consultant on geological problems related to selecting locations for instruments. He will do detailed geological mapping of the selected sites. Dr. Allen will also continue his studies of the relation of earthquakes to fault systems.

The over-all program calls for two years of investigation, with grants totaling more than $400,000 from the National Science Foundation.

"We do not expect that at the end of two years we will be able to predict earthquakes," says Dr. Allen, "but we do hope that the results of our work will point toward promising fields of research that eventually will lead to this end."