



EARTHQUAKES OR EXPLOSIONS?

by Graham Berry

A Caltech-Columbia research team finds consistent differences in the seismic wave patterns of earthquakes and underground nuclear blasts.

A seismological technique which helps to distinguish between seismic waves generated by underground nuclear explosions and those generated by earthquakes has been developed by a research team of Caltech's Seismological Laboratory and Columbia University's Lamont Geological Observatory.

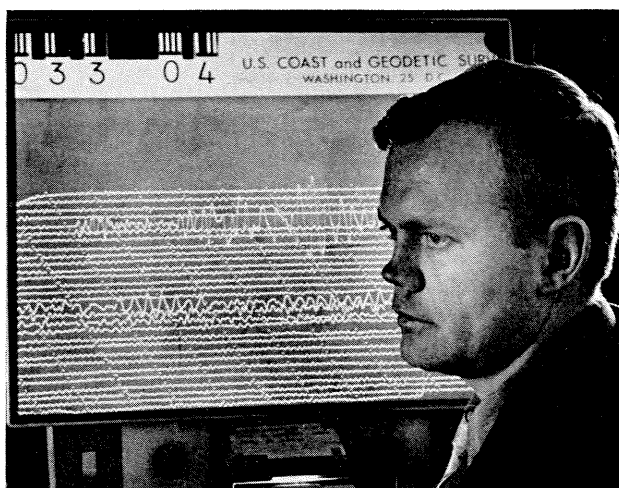
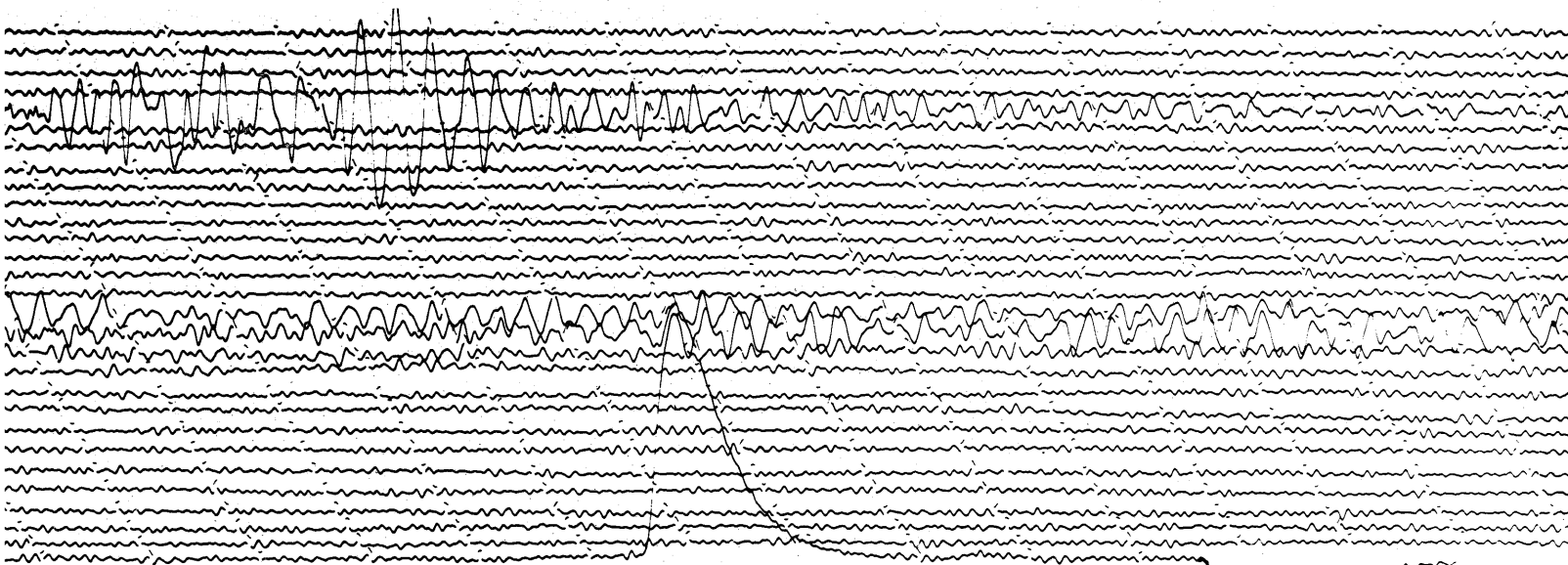
The development of this technique involved analysis and comparison of the seismic records of many small-to-moderate earthquakes and several underground nuclear explosions in a search for consistent differences that would distinguish the seismic records of earthquakes from those of nuclear tests.

Working on the project with James Brune, Caltech associate professor of geophysics, were Chi-Yu King, formerly a research fellow in geophysics at Caltech, now at UCLA; Robert C. Liebermann, a Caltech graduate of 1964, now a graduate student at Columbia; and Columbia researchers Alvaro Espinosa, Jack Oliver, and Paul Pomeroy.

In studies of records of nuclear tests made in Nevada and Alaska, and of earthquakes in Japan, Alas-

ka, and Canada, the Caltech-Columbia researchers found a consistent difference between the seismic waves of the earthquakes and the tests—a difference in the amplitude ratio of the long seismic waves to the short ones. When an earthquake or explosion occurs, long seismic waves (about 70 kilometers from crest to crest) travel *over* the surface of the earth at about 3.5 kilometers per second, and short waves (about 8 kilometers from crest to crest) pass *through* the earth at nearly 8 kilometers per second. The two types of waves are called surface waves and body waves respectively. The researchers found that for earthquakes and tests having body waves of about the same magnitude, the surface waves generated by the underground explosions were usually much smaller in amplitude than the surface waves generated by the earthquakes.

The amplitude is influenced by the size of the energy source and the velocity with which the energy is released. Earthquakes release their energy from a large volume of rock by rupturing along a



James Brune, associate professor of geophysics.

fault for perhaps several miles with a velocity of about three kilometers per second. These effects increase the relative amplitude of the long-period waves. In an explosion the rapid release of energy from a confined region produces relatively high amplitude, short-period body waves, and lower amplitude surface waves.

As a pattern emerged from the studies, the scientists decided to make detailed studies of seismic waves from explosions and earthquakes occurring in the same area in order to confirm the result. In this way they would screen out the possibility of any seismic pattern differences that might be attributed to differences in geological formations at the test sites and in the earthquake areas.

One of the areas selected for the detailed study was the region around Amchitka Island in the Aleutians, the site of the underground nuclear test Long Shot, which was detonated on October 29, 1965. Twenty-nine earthquakes that occurred in the same area in the period between March 1963 and Octo-

ber 1965 were also studied in detail.

Long Shot generated body waves of magnitude (logarithm to the base 10 of amplitude) 6.1, and surface waves of only magnitude 3.9. An earthquake that produced body waves of magnitude 6.1 would be expected to have surface waves of magnitude 5.7, i.e., about 60 times greater than observed for the explosion. In contrast, most of the 29 earthquakes (with body-wave magnitudes ranging from 7.0 to 4.5) generated surface waves with amplitudes very near those expected.

The research was supported by the Advanced Research Projects Agency, the Air Force Office of Scientific Research, the U.S. Army Research Office, and the American Chemical Society.

This proposed diagnostic aid for distinguishing between explosions and earthquakes might be important in working out an effective detection system considered necessary before the signers of the Nuclear Test Ban Treaty can discuss broadening the pact to include underground tests.