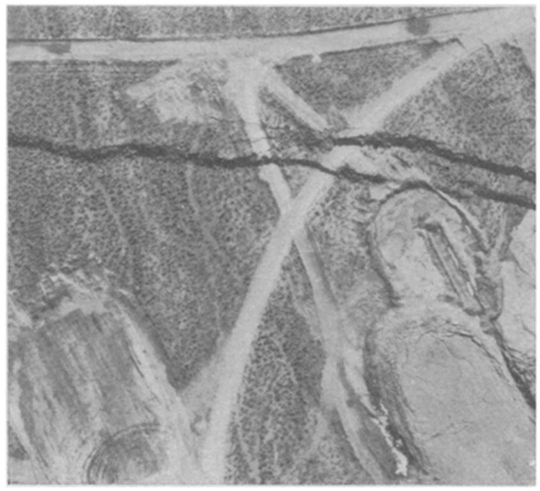
Aftershocks below, uncertainty above

The absence of earthquakes triggered by last week's Amchitka thermonuclear test has not dampened the debate



For all of man's centuries of experience with earthquakes, his knowledge about exactly how they are produced is meager. They seem to occur primarily along belts where stresses brought on by the shifts of the earth's crust produce deformations on a regional scale. Vast amounts of energy are stored in the form of elastic strain. When an instability develops along a fault, the ground slips, and energy is released. Scientists now know that even the largest earthquakes spring loose only a tiny fraction of the stored energy.

For weeks, leading up to the Atomic Energy Commission's detonation of a 1.2-megaton thermonuclear device on Amchitka in the Aleutian Islands last week, the question of whether or not such explosions can trigger earthquakes all but eclipsed other concerns about the test.

The AEC had spent those weeks trying to allay the fears, contending that aftershocks of lesser magnitude than the blast could be anticipated, but that no major disaster was possible.

The test went off without untoward incident, and the AEC felt vindicated.

But the debate about the series of tests—last week's Milrow explosion was only a calibration test to substantiate the contention that nothing would go wrong—will continue. Many scientists point out that the uneventful detonation of one device does not erase the possibility of catastrophe. And the AEC intends to explode many and larger bombs on Amchitka in the coming years, as part of the development of antiballistic missile warheads.

Much of the concern about the Amchitka series stems from recent scientific evidence that underground nuclear explosions do indeed cause small earthquakes in the vicinity of the blast.

Three underground nuclear tests carried out by the AEC in 1968—Faultless, which fissured the surface in January, Boxcar in April and Benham in December—have provided the bulk of the evidence. Dr. Keiiti Aki, a Japanese seismologist now at the Massachusetts Institute of Technology, monitored the Benham blast and recorded transverse waves in greater intensity than could be expected from the explosion alone. This and other evidence led him to conclude that an earthquake of magnitude 5.9 took place about 0.5 seconds or less after the explosion.

Dr. Alan Ryall and his colleagues at the University of Nevada have found that large underground nuclear explosions generate small earthquakes in the Nevada region for periods ranging from a few hours to at least several weeks (SN: 8/23, p. 153).

Almost all the activity, Dr. Ryall emphasizes, is limited to distances up to about 20 kilometers from the shotpoint. The Faultless explosion very likely produced minor earthquakes out to a distance of about 40 kilometers, and Dr. Ryall says now he has found no additional evidence to support a vague suggestion he reported earlier that one or two of the explosions may have had some effect on seismicity as far as 50 to 100 kilometers away. "In subsequent work we have not been able to find any triggering effects at larger distances," says Dr. Ryall. "All that we are seeing seems to be confined to very near the test area."

Recently three University of Miami scientists have compared the University of Nevada team's data with the timing of earthquakes at greater distances and concluded that underground nuclear explosions do trigger earthquakes up to at least 860 kilometers away. But Dr. Ryall says flaws in the Miami group's analysis negate that conclusion, reported in the Sept. 19 SCIENCE, and he is preparing a letter to the journal to point out why.

Nobody now doubts that underground nuclear explosions do trigger earthquakes. But all of them have so far been smaller by at least one order of magnitude than the explosions themselves, and all, if Dr. Ryall is right, have been confined to well within 100 kilometers of the blasts.

But this does not prove that the Nevada tests never will trigger more distant disturbances nor that larger tests in other regions, such as the seismically more active Aleutians, will never produce dangerous disturbances. In the minds of many, the fundamental question is not what has happened, but what could happen if the tests continue.

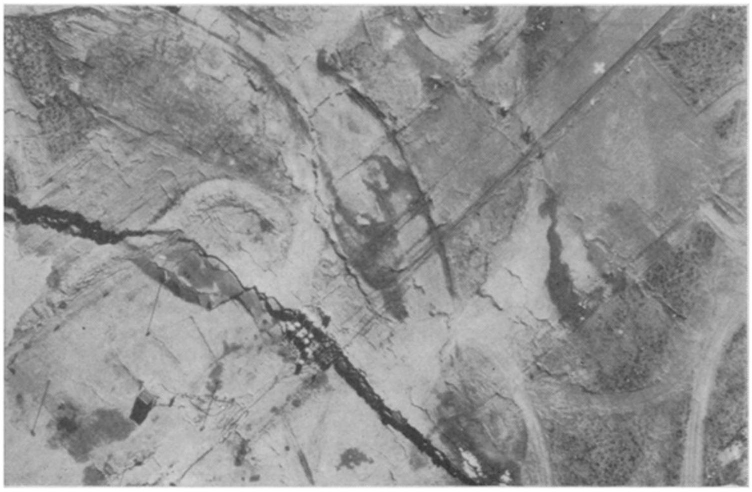
Recently Dr. James N. Brune of the California Institute of Technology has found that big earthquakes may be triggered by a succession of smaller earthquakes. The destructive Alaska earthquake of 1964 seems to have been set off in this way, and, says Dr. Brune, "There is some evidence that quite a large number of other earthquakes show a similar pattern of multiple events."

The recent Kuril Islands earthquake, an 8.0-magnitude quake in the Northwestern Pacific on Aug. 11, appears to be one in this pattern. It consisted of a series of clustered quakes of successively larger magnitudes occurring within an interval of 63 seconds. "It looks to me like this is very much like the Alaska earthquake," Dr. Brune says.

The ominous implication is that if small earthquakes can act as a trigger, an underground nuclear explosion can too.

"We know that man can trigger earthquakes artificially several ways," points out Dr. Jack Oliver, a Lamont-Doherty Geological Observatory seismologist. "We also know that very large earthquakes, magnitude 8 and above, are apparently triggered by smaller ones. So with this kind of reasoning, it seems possible that man could produce this large an earthquake, which could in turn generate a dangerous seismic sea wave," Dr. Oliver warns.

Seismic sea waves, or tsunamis, are the most feared products of earthquakes around the rim of the Pacific.



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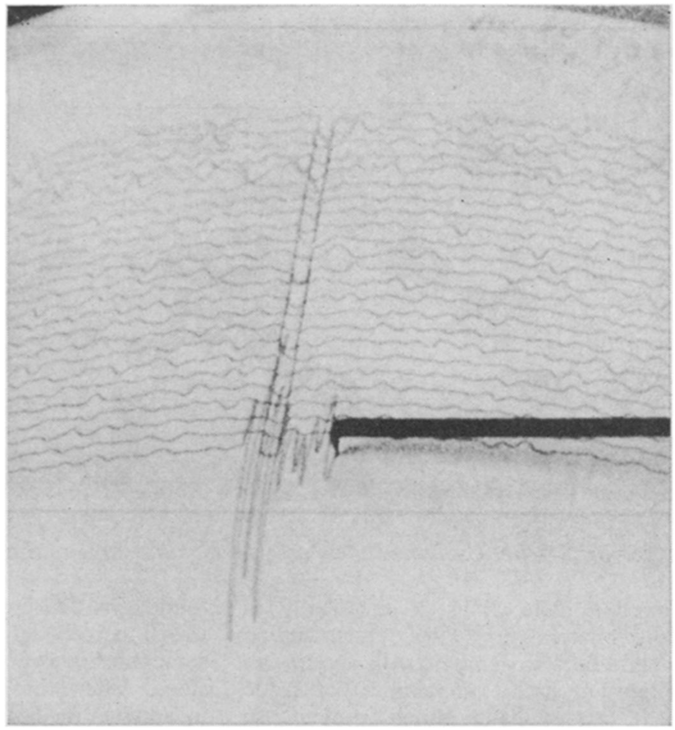


UPI

A 1968 Nevada test, Faultless, created a fissure. The Amchitka Island blast, at B, registered 6.1 on Berkeley seismograph.

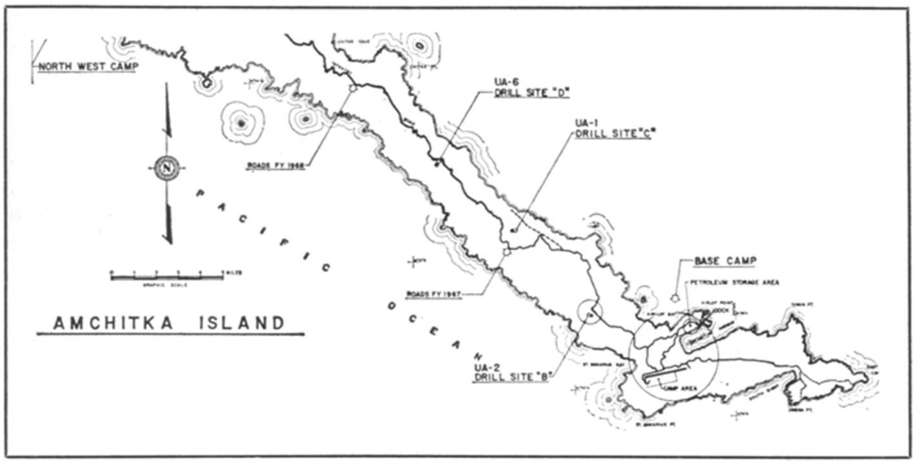
Many of the deaths from the Alaska earthquake were caused by the fast-moving tsunamis.

Looking at this new evidence, there still appears to be no systematic way to evaluate the danger involved in setting off successively larger nuclear explosions at Amchitka.

"The present level of understanding of seismic phenomena makes it difficult, if not impossible, to evaluate quantitatively the risks of conducting large underground tests in seismic regions," states the report of a panel on the safety of underground testing headed by Dr. Kenneth S. Pitzer of Stanford University. But it was studies such as these that led the Pitzer panel to voice serious concern about the earthquake possibilities following blasts at Amchitka. "The risk seems to be small but not insignificant since the consequences of accidentally releasing a large amount of tectonic strain energy could be extremely serious," it contends. "After much study we might a few years from now be able to say there is a one in one hundred chance or one in a million chance of something happening," says Dr. Brune. "Then if we could rate the risks of earthquakes we could compare them with other risks, and with the advantages. But now the public is asked to take this risk without knowing what it is . . ."

The successful detonation of the first nuclear device at Amchitka without incident, or "just as we predicted," as the Atomic Energy Commission put it, should intensify, not moderate, the debate about the test series, says Dr. Gordon J. F. MacDonald of the University of California at Santa Barbara. He was a member of the Pitzer panel.

"It may be that the energy stored in the ground beneath the test site isn't great enough to be released by the blasts," he says. "But the information about Amchitka is very sketchy, and I don't think the evidence is in either way." □



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MAN-MOUSE HYBRID

Mapping the genes

Maps of chromosomes already exist for bacterial genes, forming the intellectual backbone of some important genetic concepts. Gene mapping, for example, made possible the Nobel Prize-winning Jacob-Monod hypothesis that there are two classes of genes: one determining the amino acid sequence and hence structure of proteins and another controlling the function of those structural genes. Likewise, the operon theory that genes sitting side by side on a single chromosome operate as a unit depended on chromosomal maps.

Now, from the union of man and mouse, geneticists are compiling an atlas of human genes. Within four or five years, Dr. Frank H. Ruddle of Yale University predicts, it will be possible to draw maps of each of man's 23 pairs of chromosomes, at least outlining the geographical location of specific genes for specific human traits.

And, though Dr. Ruddle and his colleagues have little understanding of the mechanism of hybridization, they foresee additional implications not only for genetic counseling, but for cancer research as well.

Hybrid cells are an essential and simple tool with which to approach genetic mapmaking, Dr. Ruddle told the American Society of Human Genetics meeting in San Francisco last week, because they possess three special attributes:

■ Human and mouse enzymes that