HONOMU, HAWAII EARTHQUAKE OF APRIL 26, 1973

by

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SYNOPSIS

The Richter magnitude 6.2 earthquake was deep seated (50 km). A strong motion accelerograph was located about 50 km from the epicenter, the maximum recorded acceleration was 0.17 g, the duration of the strong motion was short (7 sec). Sensitive aftershock equipment was installed on two different types of soil, hard lava rock and soft volcanic ash. The aftershock records were analyzed and response spectra were calculated. The response, for most frequencies, was considerably higher for the volcanic ash. Total amount of damage was $6,000,000. A significant portion of the damage was to roads and bridges.

SEISMOLOGICAL DATA

The island of Hawaii is the seismically most active of the Hawaiian Islands. Since 1929 twelve earthquakes of magnitude 6 or larger have been recorded. There are two volcanoes on the island that are still active. However, for larger earthquakes there seems to be no connection with volcanic activity. At the time of the earthquake the Kilauea Volcano was in active eruption but the epicenter was far removed from the volcano. The earthquake occurred on a known fracture zone; the depth of focus was approximately 50 km; usually Hawaiian earthquakes occur at much shallower depths. The magnitude of the earthquake was 6.2. The epicenter was located at Honomu which is 10 km north of Hilo and about 2 km inland. About two months before the earthquake occurred two strong-motion accelerographs and four seismoscopes were installed in the islands. One of the strong motion accelerographs was installed at Kilauea on the island of Hawaii; its distance from the epicenter was 50 km. Another accelerograph was installed in Honolulu about 300 km from the epicenter. Both instruments were triggered by the earthquake and the first strong-motion accelerograms were obtained in Hawaii. The maximum acceleration at Kilauea was 0.17 g and the strong ground motion lasted about seven seconds. The accelerograph record was digitized and Figure 1 shows a plot of the resulting velocity response spectra. A seismoscope was located alongside the accelerograph and its S_d value is represented by the black dot near the 10 percent damping curve. The Honolulu record showed a maximum acceleration of 0.03 g. Three days after the earthquake additional instrumentation was flown in from Las Vegas to enable monitoring of aftershocks. The aftershock monitors recorded approximately 10 shocks of magnitude between two and three.

The Wailuku River which runs into the ocean just north of downtown Hilo is the dividing line between the Mauna Kea and the Mauna Loa flows. Mauna Kea is the older volcano and Mauna Loa is younger and still active.

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At the last stages of the volcanic activity of Mauna Kea, ash deposits from the volcano covered the northeast portion of the island north of the Wailuku River. The result is that soil conditions are quite different on the two sides of the river. North of the river the ash cover is about 5 to 10 m thick. The ground south of the river is lava rock. It was evident from the earthquake damage that the behaviour of the two soils were different, the damage seemed to be much heavier on the volcanic ash north of the river.

The seismic data from a selected aftershock, which was approximately 50 km from two of the aftershock monitoring stations, was analyzed by deriving a pseudo velocity reponse (PSRV) spectrum from the data. One station was located near the Hilo campus of the University of Hawaii on a deep, weathered lava flow; the comparison station was located in the northern part of Hilo on a relatively extensive volcanic ash bed. The PSRV spectrum is derived from the seismic trace by digitally filtering the data and calculating the peak response of a series of single-degree-of-freedom systems to the ground motion. The systems were arbitrarily damped at 5 percent. Figure 2 shows the PSRV spectrum derived from the horizontal data. The spectrum for the lava station indicates a single response peak in the period range of 0.3 to 0.1 sec, with attenuation (or reduced response) at the shorter and longer periods. The spectrum for the ash station is markedly different than that found on the lava. The response is complex with at least three bands of periods with high response. These bands are found in the 0.09 - 0.07, 0.50 - 0.03, 5.0 - 3.3 sec ranges. The motion on the ash was at a considerably higher amplitude than that on the lava.

Even though the earthquake damages were minor structurally, the performance of the volcanic ash over the lava bedrock was unique. The natural water content of the volcanic ash is about 200% except for surface layers which may be less than 100% in localized areas. The annual rainfall and liquid limit approximate the natural water content of the soil. The degree of saturation is about 95 to 100%. The material plots below the "A" line on the Casagrande plasticity chart. On air drying, the liquid limit and plasticity index usually decreases and the material behaves much like a slightly cemented granular material.

The earthquake followed general patterns of large earthquakes, magnitude ≥ 6, in Hawaii. These earthquakes seem to come in clusters chronologically at 11 year intervals. The earthquake was not associated with any center of volcanism, although Kilauea Volcano was in active eruption at that time. The epicenter fell on a known rift zone, the Mauna Kea Primary Rift Zone. All the other past large earthquakes on or near the island of Hawaii occurred on or very close to identified rift zones or faults and were never near centers of volcanism. The fault plane solution of the Honomu earthquake agreed to the degree with the source solution of the 1962 Kaoiki earthquake. This seems to point to a consistent pattern of stresses acting in the Hawaiin region. The fault plane solution can be interpreted two ways. One is that a set of forces are acting outward against the walls of the Mauna Kea Rift Zone. The other is left lateral horizontal motion across the rift zone. The second interpretation is preferred as it is more consistent with calculated fault area. Calculation of source parameters resulted in a low stress earthquake. This is added evidence to the proposition that the lithosphere in the Hawaiian Region is weak. However, this does not rule out large earthquakes as the fault area can be large. Furthermore, historically there has been an earthquake of magnitude 7-3/4 in 1868. The low stress drop and weak lithosphere can be attributed to the relatively high heat content in the area. Although Mauna Kea Volcano has long been extinct, the residual heat remaining there may well be an effective factor in lowering the rigidity of the lithosphere in its neighbourhood. However, we do not consider the residual heat of Mauna Kea Volcano as the source of the energy of the earthquake. The focal mechanism solutions of left lateral motions point to a set of forces acting regionally.

EARTHQUAKE DAMAGES

Damages were rather minor considering the magnitude of the earthquake (6.2). This can be attributed to several facts. 1) The earthquake was very deep-seated (50 km); 2) The duration of the strong motion was short (7 sec); 3) The island of Hawaii is sparsely populated; the total population of the island is 70,000, of this total 30,000 live in Hilo. There are very few tall buildings in Hilo; most are one - or two - storey residential units. The total amount of damage has been estimated at $6,000,000. A significant portion of this was damage to public roads and bridges. Numerous land and rock slides occurred in the northeastern portion of the island. Most of the damage to residential units occurred to buildings located on volcanic ash deposits within about a 20 km radius of the epicenter. There was a good deal of "non-structural" damage. Many students in school buildings were injured from falling light fixtures and false ceilings. Many residential units were shifted on their foundation; it was evident that an earthquake of longer duration would have caused considerably more damage. One 15-storey shear wall building about 18 km from the epicenter had cracks in the shear walls at the first storey level; it also suffered a good deal of "non-structural" damage, in addition its elevators jumped their tracks. The 8-storey Mauna Kea Beach Hotel, about 75 km from the epicenter suffered "non-structural" damage; the damages were from minor design details. Foot bridges connect the various wings of the hotel; the bridge seats were designed for sliding but apparently dowels were installed in the field resulting in a good deal of spalling. Where additions were made to an elevator tower cracks showed up in the joints. The damage to power lines, water supply and telephone lines was severe. The northeastern portion was in a state of emergency for several days. In Honolulu, about 300 km from the epicenter, the damage was very minor; some pendulum clocks stopped and there were minor plaster cracks. Apparently, the long period waves arriving coincided rather closely with the natural periods of some of the tall (20 - 30-storey) buildings resulting in sways of relatively large displacements. Near panic broke out in several buildings. There was no evidence of liquifaction even though the volcanic ash tends to liquify under traffic of heavy construction equipment. The intensity distribution, Figure 3, is based on 500 damage reports and Geodetic Survey questionnaires which were sent to all postmasters in Hawaii.

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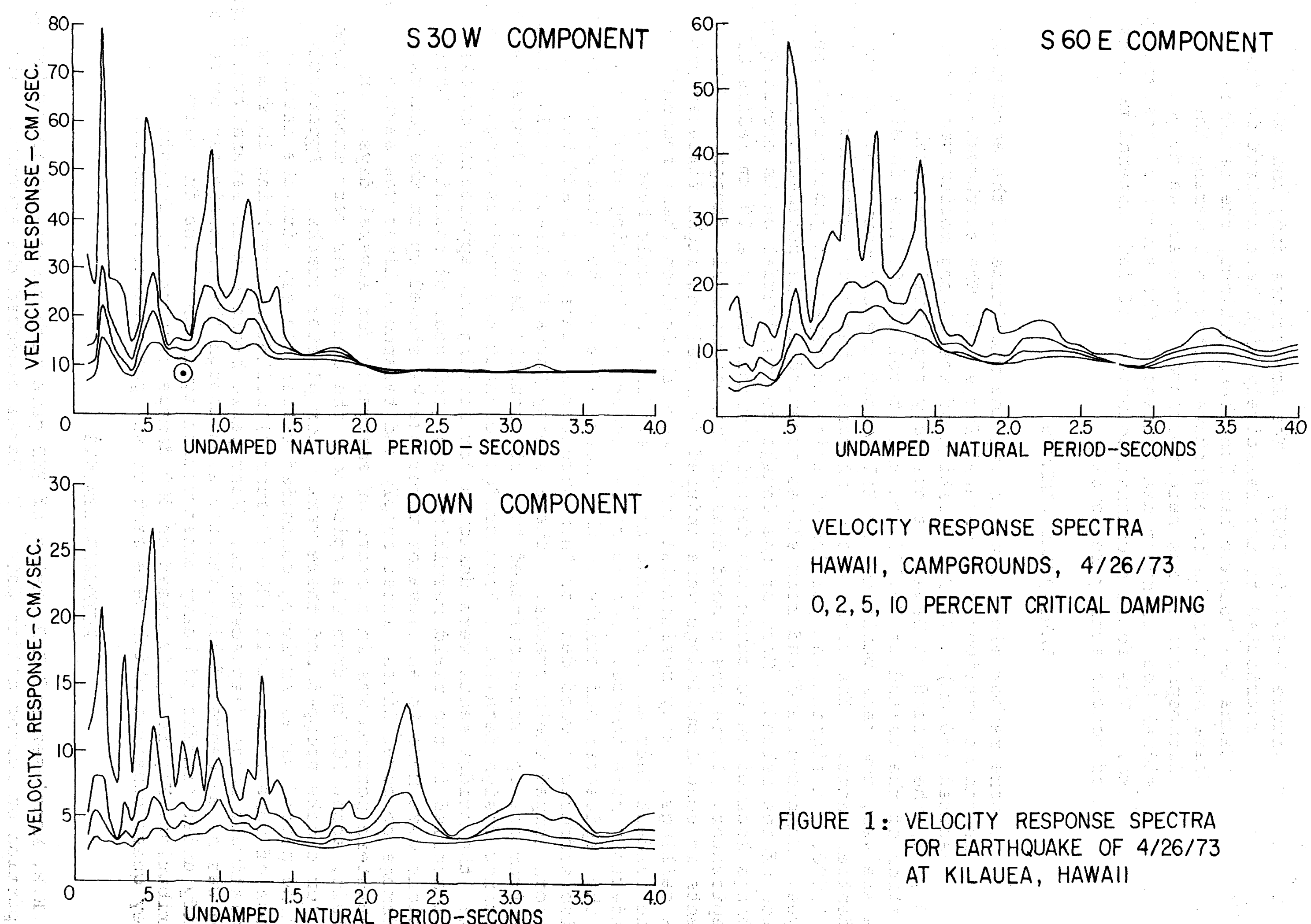

FIGURE 1: VELOCITY RESPONSE SPECTRA FOR EARTHQUAKE OF 4/26/73 AT KILAUEA, HAWAII

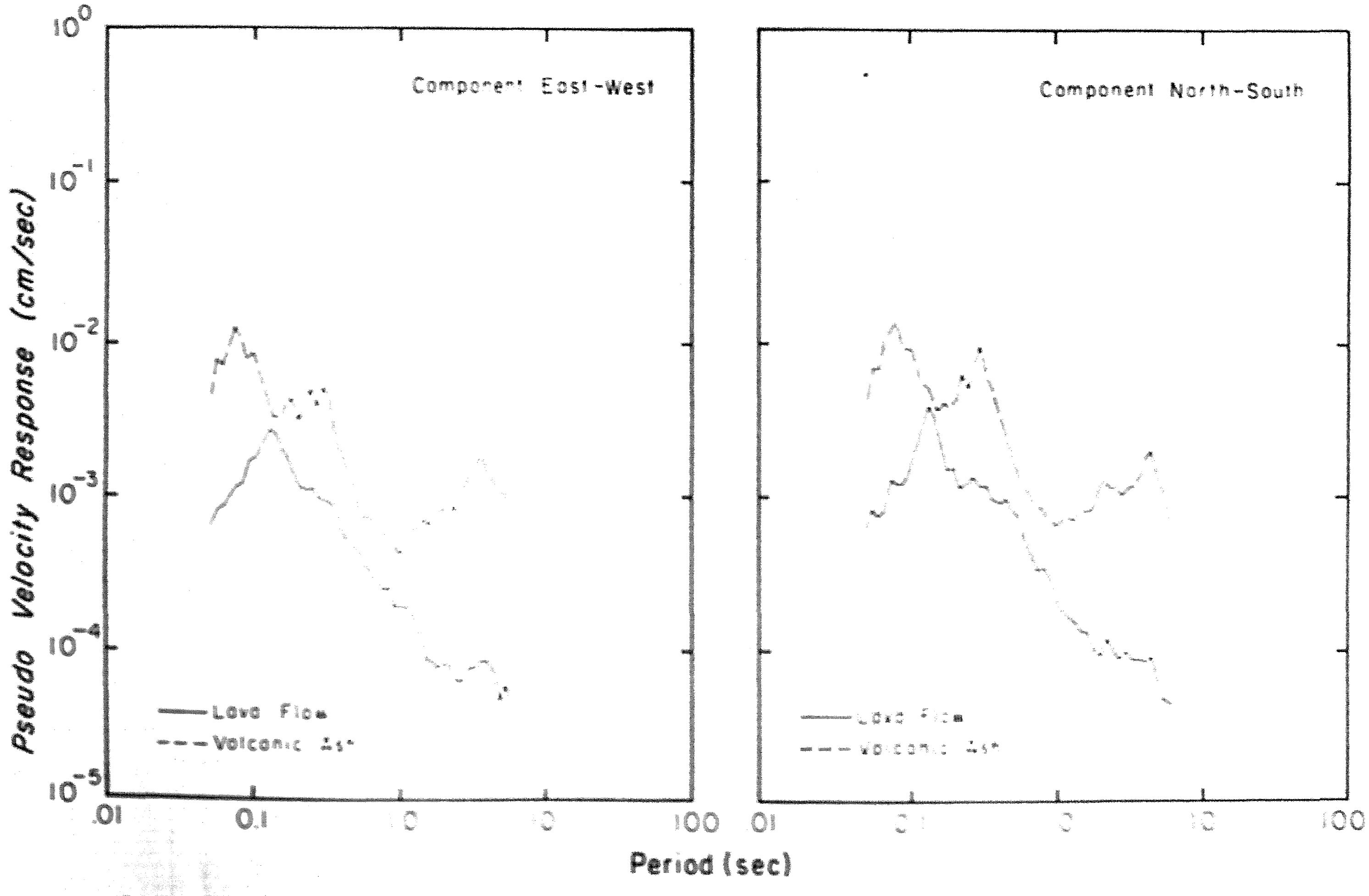

FIGURE 2: RELATIVE RESPONSE ON VOLCANIC ASH AND LAVA FLOW AT HILO, HAWAII

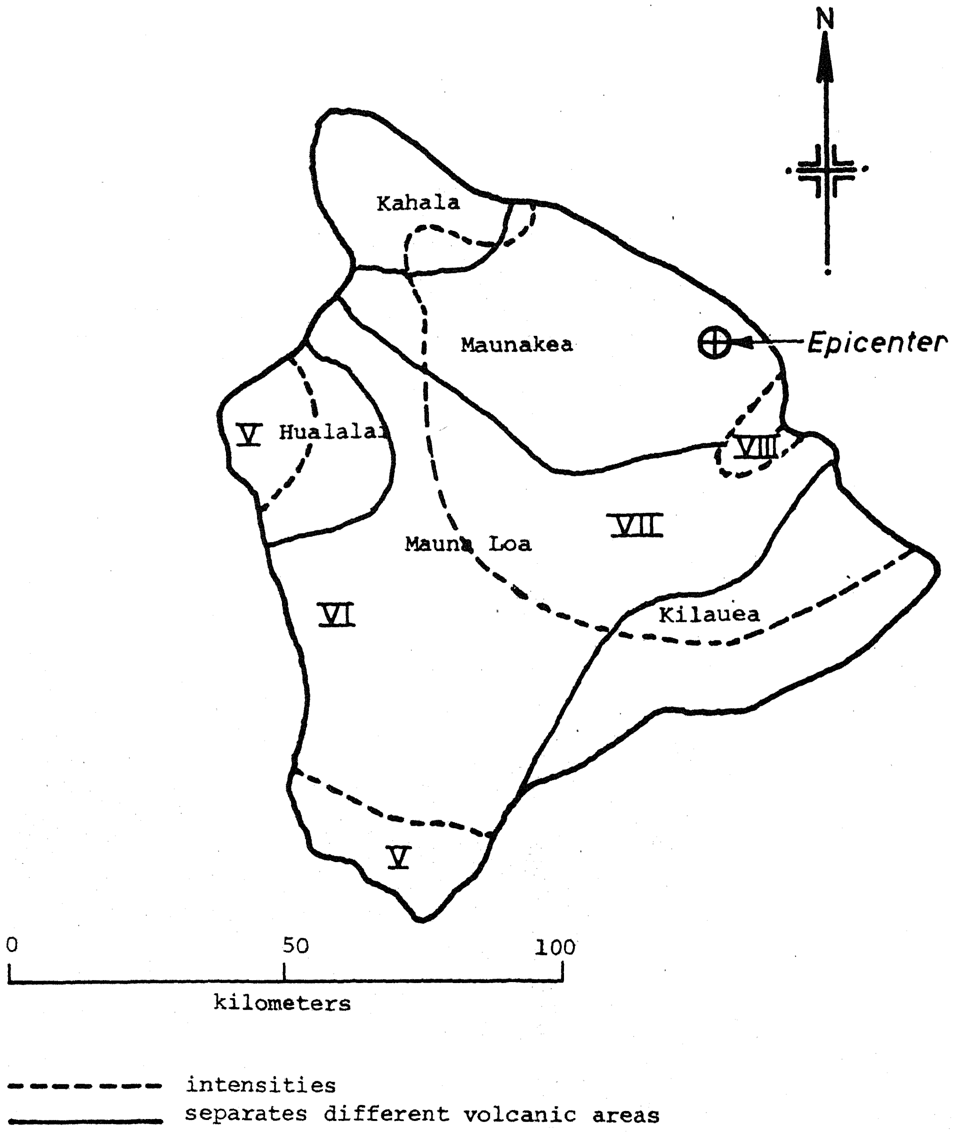

FIGURE 3 SEISMIC INTENSITIES, ISLAND OF HAWAII