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Seismic Noise Surveys in Geothermal Areas[1]

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Some evidence suggests that high seismic noise levels are associated with geothermal systems. Clacy (1968) and Whiteford (1970) found that large seismic amplitudes, in the frequency range of 1-10 Hz, occur in the vicinity of known geothermal areas in the North Island of New Zealand. In Imperial Valley, California, Goforth, Douze and Sorrells (1972) found a seismic noise anomaly that nearly coincides with a thermal anomaly near the southeastern shore of Salton Sea, and Douze and Sorrells (1972) found high noise levels over the Mesa thermal anomaly.

The U. S. Geological Survey (USGS) made seismic noise measurements in Imperial Valley and Long Valley, California, and Yellowstone National Park, Wyoming, to evaluate whether seismic noise can be used as a prospecting tool in geothermal exploration. One Hz seismometers with slow-speed tape-recording systems were used. About 50-80 stations were occupied with average spacing of 0.5-1.5 km, and each station was operated for at least 48 hours. The results described below are based on average noise amplitudes computed using playbacks of several sections of data recorded at night when wind-generated noise was absent.

1 Presented by Peter L. Ward

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At Yellowstone, high noise levels were found to be associated with all the major thermal areas in the park (Iyer and Hitchcock, 1974). Noise levels in the Upper and Lower Geyser Basins and Norris Basin are 10-50 times higher than the background value outside the basins (see bottom and center left of Figure 1). These basins have many surface expressions of geothermal phenomena. Noise measurements were made close to Old Faithful Geyser to determine whether the surface activities produced the high noise field. Analysis of data recorded during several eruption cycles shows that high-frequency noise above 8 Hz increased during eruptions whereas noise in the 2 to 8 Hz band remained fairly constant. Since most of the seismic noise energy at all geyser basins in Yellowstone is in the low-frequency band, we postulate that it is generated at depth, probably by convection systems that cause the surface phenomena. Mammoth Hot Springs, though cooler and relatively more passive than Norris, Lower, and Upper Geyser Basins, seem to generate significant noise levels (see top of Figure 1). High noise amplitudes are associated with the waterfalls in the canyon of the Yellowstone River (see center right of Figure 1). Waterfall noise has a frequency of about 2 Hz and is clearly different in appearance from the noise observed elsewhere in Yellowstone. The noise level remains high for about 15 km to the south of the waterfalls, whereas to the north and west it decreases to a small value within 4 km. Geothermal activity is associated with the Mud Volcano towards the lower part of the traverse. The region to the south of the waterfalls is covered by unconsolidated sedimentary deposits, and at present we are unable to separate the contributions from the river, ground amplification effects, and geothermal sources to the seismic noise observed here.

Long Valley, about 40 km south of Mono Lake, in California, is a resurgent caldera with a history of active volcanism prior to about 100,000 years. There are some hot springs and geysers in Long Valley, but the surface activity is on a much smaller scale than in Yellowstone. Our survey revealed an extended noise high covering the entire northeast section of the caldera (Iyer and Hitchcock, 1973), almost coinciding with the unconsolidated sedimentary basin to the north of the region where most of the surface geothermal phenomena exist. Studies using earthquake waves show that seismic signals are amplified by about five times by the basin. Noise amplitude at the peak of the anomaly in the basin is higher than that outside the anomaly by a factor of 25. A possible interpretation is that either a noise source is present under the basin or the geothermal activity at depth, which produces the hot springs to the south, excites the basin much more than the harder ground near the springs.

There are several thermal anomalies in Imperial Valley, California. The one at Mesa to the east of Holtville is particularly interesting as two test wells have been drilled over the anomaly by the U. S. Bureau of Reclamation. Unfortunately, it is situated close to a busy freeway and agricultural region. Our survey showed only the presence of cultural noise from these sources in the region. If a geothermal noise anomaly is present, it is masked by the high cultural noise, and hence it is only possible to guess an upper limit for noise amplitude in the anomaly (Iyer, 1972). Douze and Sorrells (1972), however, found a noise anomaly to correspond to the Mesa thermal anomaly. The difference between these results is probably due to the ambiguity in separating cultural and natural noise.

We conclude from these experiments that seismic noise in the frequency range of 2-8 Hz seems to exist in geothermal areas and is probably generated at depth by convection systems. Considerable caution should be exercised in interpreting a noise anomaly as the existence of cultural noise sources and unconsolidated sedimentary deposits can complicate the picture.

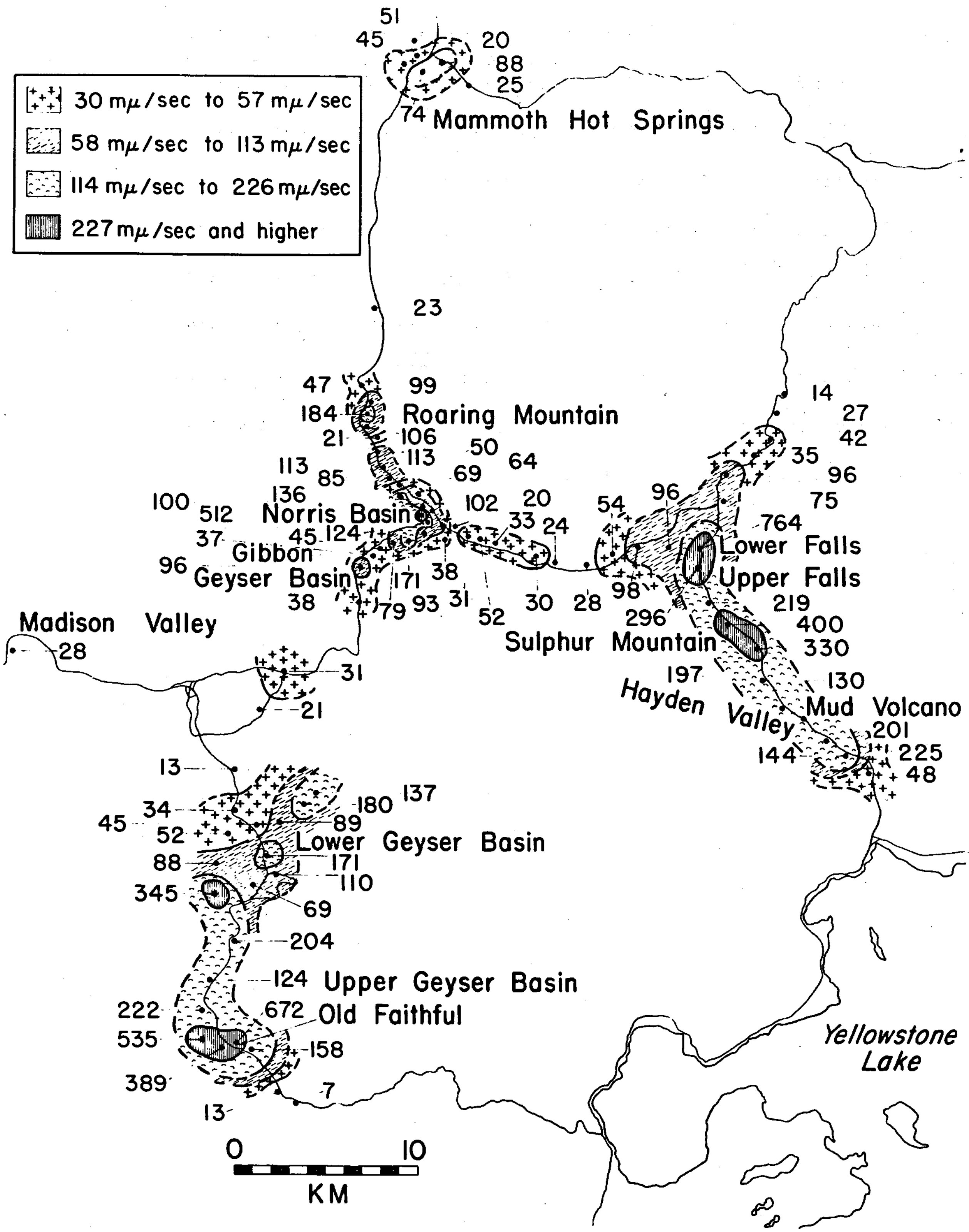

Figure 1. Map of Yellowstone National Park showing the variation of average seismic amplitude. The numbers are in units of ground velocity, millimicrons/sec. The contour intervals represent doubling of seismic level. Broken lines show uncertainty in contouring.

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