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VOL. 73, NO. 16, AUGUST 15, 1968

Geothermal Ground Noise Amplitude and Frequency Spectra in the New Zealand Volcanic Region

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A survey made with a portable slow-motion tape seismograph of the Rotorua, Taupo volcanic region, showed that areas of continuous high seismic noise and low dominant frequencies were found in conjunction with aquifers.

INTRODUCTION

Owing to ground unrest in the Rotorua, Taupo, volcanic region of New Zealand, survey work by various geophysical methods has been hampered. A constant high seismic noise level is encountered for most of the region. It was decided to record this phenomenon. The instrument chosen was a continuous direct-recording tape seismograph and Willmore seismometer, which was described by *Dibble* [1964]. The method of measurement and the final plotting on maps were devised by the author as the survey progressed, and the total amplitude from 1 to 20 cps was plotted and contoured. The dominant continuous frequency in the same frequency range is described below.

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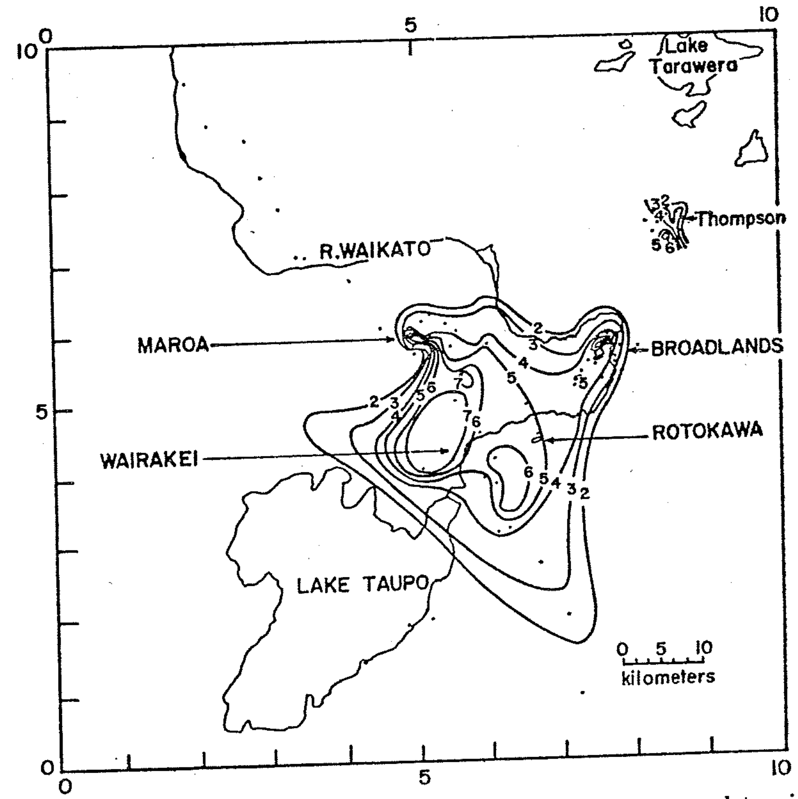

Fig. 1. Over-all total noise amplitude from 1 to 20 cps relative to a predetermined level. Recording stations covering the Taupo volcanic region are shown by the solid dot.

Precautions were taken to ensure that any sudden increases in ground noise would be known and could be calculated for.

Discussion of Results

Recordings made during 1966 are indicated by dots on Figure 1. This map also shows that the over-all contours of relative total ground-noise amplitudes, which are derived from the continuous frequency bands 1–20 cps, are logarithmic in scale and do not include man-made noise, winds, ocean microseisms, or other periodic surface seismic noise. The exclusion of noises is simple, because they are readily spotted during the frequency analysis process and because periods free of these spurious noises occur during the night.

On the amplitude basis in Figure 1, it is easy to see areas of noise and quiet and to find areas that require more detailed survey. The Broadlands area was surveyed with approximately 914.4 meters station separation. From this survey, maps (Figures 2 and 3) were prepared. Figure 2 shows fairly well defined high-noise areas, and Figure 3 shows the frequency distribution over the same area. It will be noticed how the lower-frequency dominant continuous noise moves up in frequency away from the high-noise source.

A further interesting survey with bore 2 running was made using the same survey stations in the Broadland area. The records of this survey are plotted in Figures 4 and 5. As one would expect, the total noise in the immediate area of the bore increased, as did the dominant frequency. The hitherto high-noise area of 6.5 increased only slightly, however, and the seismic noise from the bore decreased more rapidly toward this point. The dominant-frequency pattern emerged around the bore

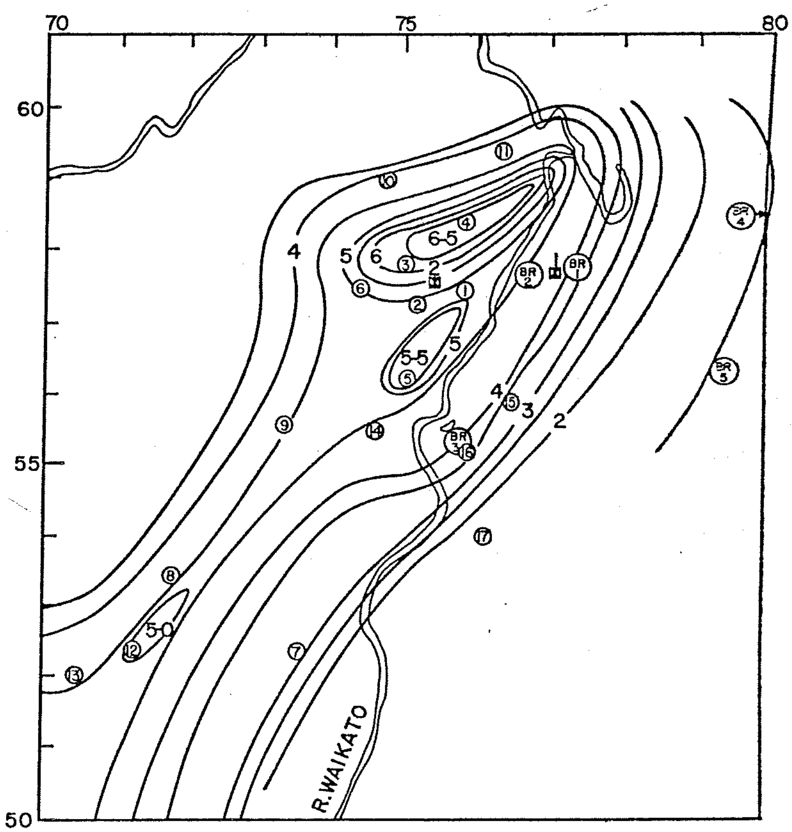

Fig. 2. Over-all total noise amplitude from 1 to 20 cps. The recording stations are shown by the open circles, and the bores are shown by the solid squares. Bores 1 and 2 closed in the Broadlands geothermal area during the survey.

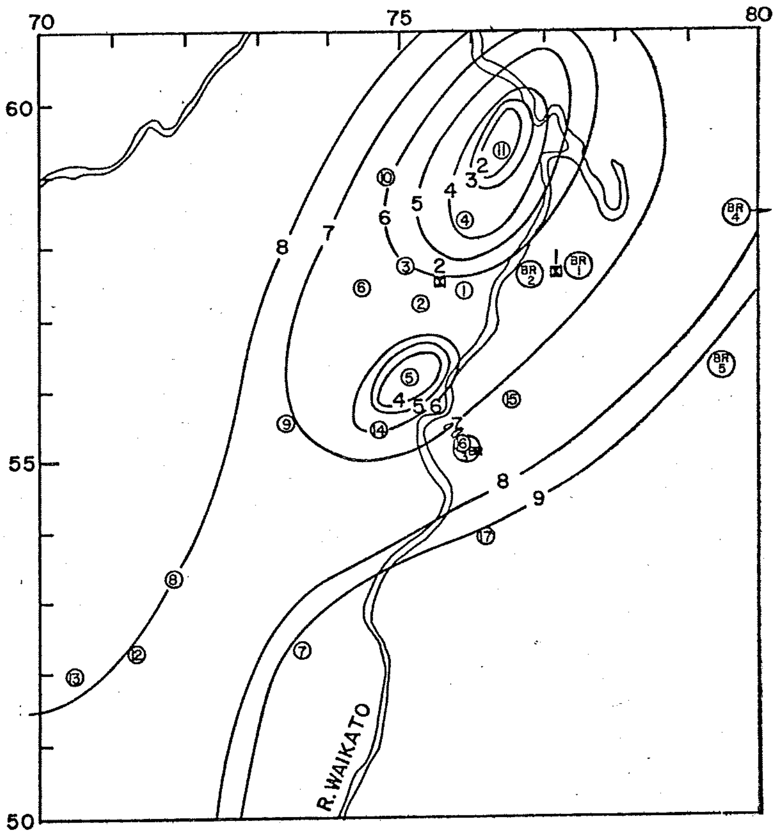

Fig. 3. First dominant frequency from 1 to 10 cps. The recording stations are shown by the open circles, and the bores are shown by the closed squares. These contours apply to the same conditions as Figure 2.

it at higher frequency; it emerged from the ore area with increasing frequency away om the noise source.

In the Maroa region, which is a fairly young lcanic center (Figure 6) with no obvious rface activity, a high seismic noise pattern present but no frequency analysis has yet en made for this region.

The Waiotapu Thompson area shows an in-resting noise pattern (Figure 7): small and little more complex. The frequency spectrum ot shown) is quite complex, but the 2-cps equency does emerge in the high-noise area. bvious surface activity occurs where the ores are. These bores are not, however, good roducers, so that the aquifer system is per-aps located where the high noise, low fre-uency appears.

Conclusions

The seismic-noise pattern of a geothermal region is probably a useful method for determining an underground steam-producing aquifer because the water contact with heat appears to produce a useful seismic noise pattern that can be plotted to determine the possible extent of an aquifer. In Figure 8 the emergence of 2 cps as the dominant frequency is probably due to the attenuation of the higher ferquencies. As the travel paths improve, the higher frequencies become the dominant ones. The direction of the aquifer depends on the rate of emergence of the higher frequencies, as does the size of the aquifer. The mechanism in Figure 8 suggests water supported by gas vapor, as in the Liedenfrost effect. This condition could account for the 2-cps emission,

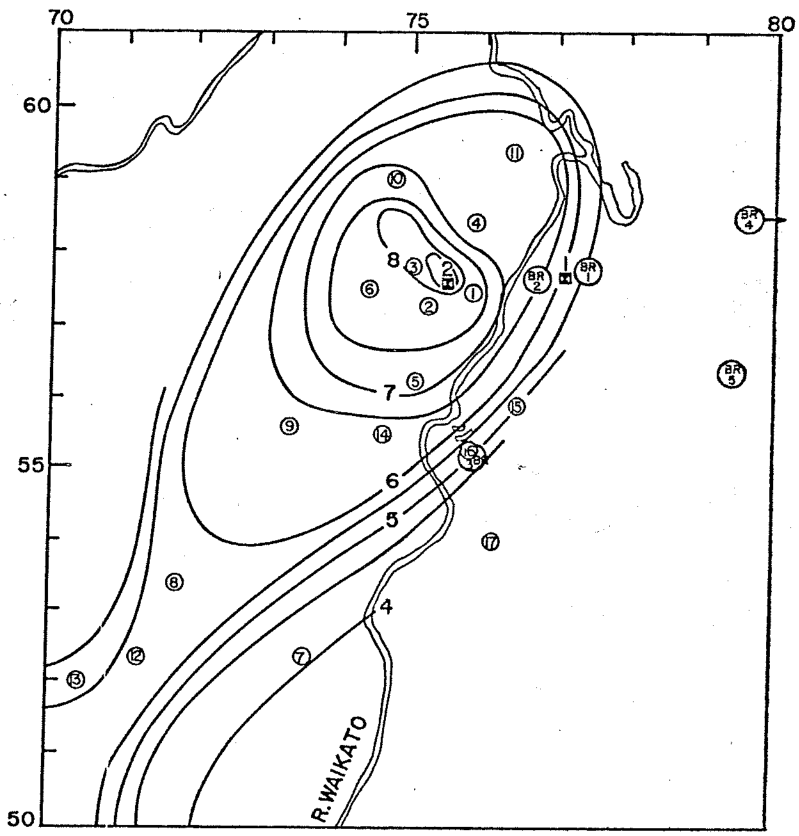

Fig. 4. Over-all total noise amplitude from 1 to 20 cps relative to a predetermined level. Recording stations are shown by the open circles, and bores are shown by the closed squares. Bore 2 was producing steam. Bore 1 closed in the Broadlands geothermal area during survey.

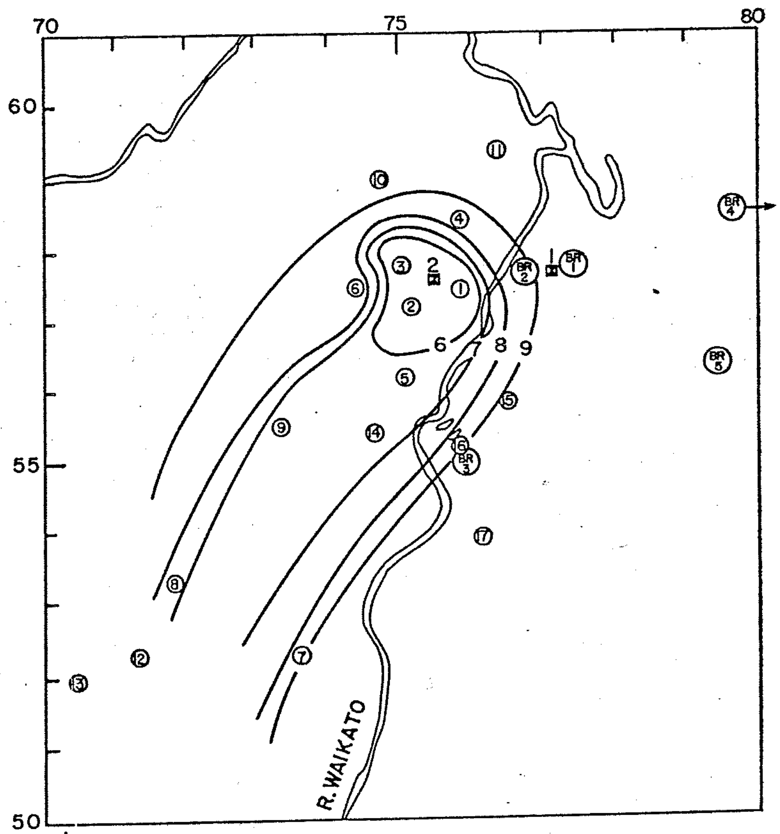

Fig. 5. First dominant frequency from 1 to 10 cps. These contours apply to the same conditions as Figure 4.

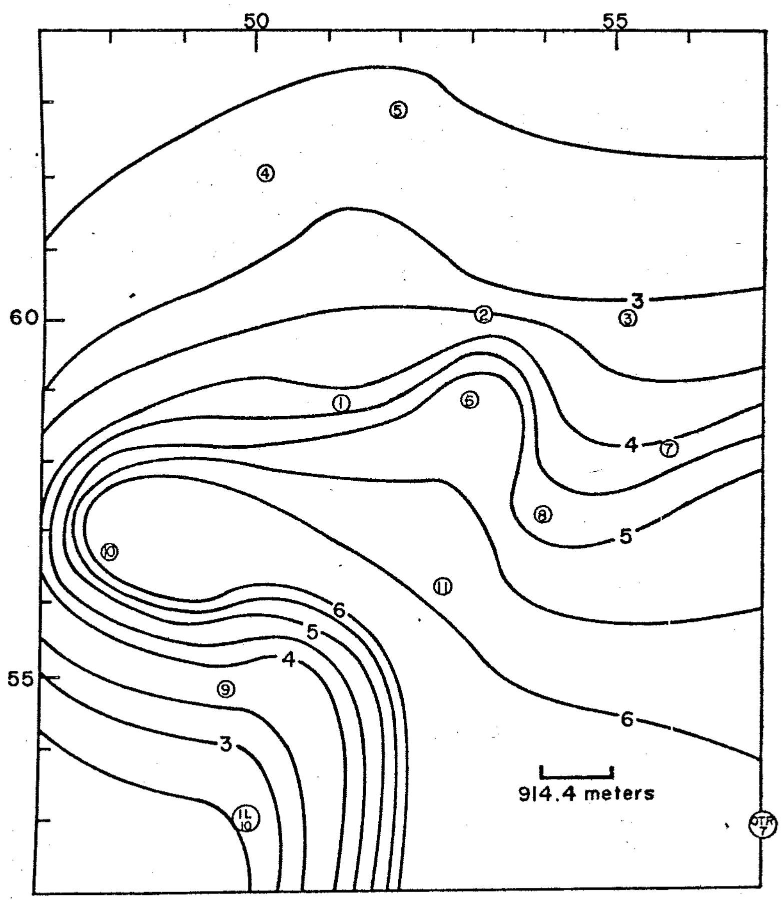

Fig. 6. Over-all total noise amplitude from 1 to 20 cps relative to predetermined level. Recording stations are shown by the open circles in the Moroa Geothermal region.

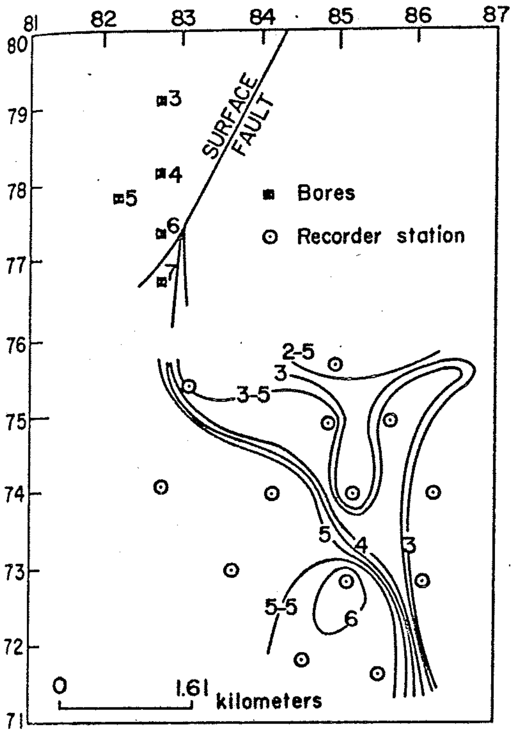

Fig. 7. Over-all total noise amplitude from 1 to 20 cps relative to a predetermined level. Recording stations are shown by the open circles in the Thompson-Waiotapu geothermal region. The bores are shown by the closed squares.

with water in contact with lower heat around the perimeter giving the higher-frequency dominances. The cooling and regeneration of heat source will give rise to many other frequencies. I think that a multiple noise generator is necessary because of the many discrete narrow-band frequency dominances recorded at one time, though all frequency dominances are low in the center of a good aquifer system. Therefore, high-noise and low-frequency dominance indicates a good aquifer.

Acknowledgments. I thank Dr. T. Hatherton and Mr. C. J. Banwell for their advice and encouragement and Mr. D. J. Dickinson for his field assistance.

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(Received November 9, 1967;
revised January 22, 1968.)

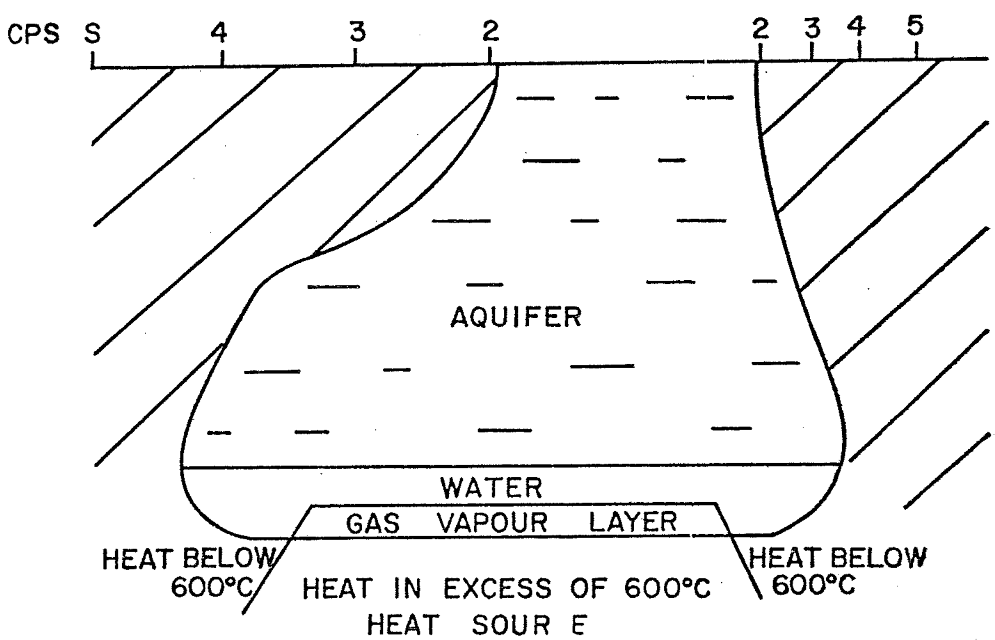

Fig. 8. Proposed model of geothermal groundnoise source indicating zone of high-frequency attenuation.