UNITED STATES DEPARTMENT OF INTERIOR

GEOLOGICAL SURVEY

PRELIMINARY OBSERVATIONS OF NOISE SPECTRA AT THE SRO AND ASRO STATIONS

by

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

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INTRODUCTION

The seismic noise spectra presented in this report were derived from SRO and ASRO station data for the purpose of evaluating the performance of the seismic instruments. They are also useful for constructing a spectral estimate of earth noise at a quiet site based on noise samples obtained from a network of globally distributed sites. It is hoped that the spectra will be useful for other purposes as well.

The term "noise" is used here to describe the ambient signals recorded during a quiet period when earthquake signals have not been detected by a visual inspection of the analog seismogram. The total recorded noise is the sum of instrumental noise, environmental noise (such as effects of temperature, pressure, wind), earth background noise from both natural and cultural sources, and very possibly low-level signals from earthquakes that cannot be visually identified. It is not possible to separate and quantify the signals generated by these independent noise sources using a single sample of station data, although instrumental problems may be indicated by gross changes in noise levels, if the changes are not in the microseismic bands. Since seismic data at the SRO and ASRO stations are recorded in a digital format, spectral computations can be automated so that station noise levels can be monitored as part of data-review procedures. The noise spectra presented in this study are intended to serve as an initial baseline against which relative changes in noise levels can be measured.

Total noise power was computed separately for the short- and long-period bands, which are recorded separately at the stations. Power spectral densities were derived by averaging the spectral estimates of a number of contiguous data segments. The mean value and slope were removed from each segment, cosine-tapered windows were applied, and the estimates were obtained using a fast Fourier transform. In the short-period analyses 16 segments were used, each segment being 1024 samples in length. Because the sampling interval is .05 seconds, the total record length is nearly 13.7 minutes. Normally, the short-period SRO and ASRO data are recorded in an event-only mode. However, several days of continuous short-period data were acquired from most stations for the purpose of this study. Where there was an appreciable diurnal variation in short-period noise, spectral data were computed for both day and night intervals. In most cases the long-period spectral densities were obtained by averaging the estimates from 16 data segments, each segment having a length of 2048 samples. Since the long-period sampling interval is 1 second, the total record length used was nearly 9.1 hours. In a few instances, a smaller number of segments was averaged. Spectral data were computed from the vertical-component short-period signals and all three components of long-period signals. All of the spectral plots have been corrected for known instrument response and presented in units of earth displacement.

With a few exceptions, the samples of noise data used were acquired during the early months of 1980, winter at some of the stations and summer at others. The starting times for the intervals analyzed are listed in Table 1. A seasonal variation of noise levels in the microseismic bands is to be expected. However, none of the stations were experiencing a noticeably high level of microseisms during the intervals analyzed. Weltman and others (1979) have studied and reported daily and seasonal RMS (root-mean-square) noise trends at the SRO and ASRO stations.

SRO DATA

Short-period power spectral densities computed for each SRO station are shown in Figures 1 through 4. As one would expect, short-period noise levels vary over a wide range as a function of station location, the noisiest sites being the island and coastal stations and the quietest sites being inland. Cultural noise is manifested principally in the .1- to 1-second period band; diurnal variations in noise levels are not significant above a period of

Station Code	Station Location	Component	Start Time (y:d:h:m:s)	Number Segments
SRO STATIONS:				
ANMO	Albuquerque, New Mexico	SPZ	9:305:00:11:19.91	16
		LPZ	0:065:13:55:45.21	16
		LPN	0:065:13:55:45.21	16
		LPE	0:065:13:55:45.21	16
ANTO	Ankara, Turkey	SPZ	0:049:23:00:28.91	16
		LPZ	0:079:14:36:43.91	16
		LPN	0:079:14:36:43.91	16
		LPE	0:079:14:36:43.91	16
BCAO	Bangui, Central African Republic	SPZ(D)	0:043:09:14:31.22	16
		SPZ(N)	0:043:21:59:44.22	16
		LPZ	0:067:11:54:47.76	16
		LPN	0:067:17:35:47.76	9
		LPE	0:067:17:35:47.76	9
BOCO	Bogota, Columbia	SPZ	0:044:02:59:34.91	16
		LPZ	0:041:19:59:02.91	16
		LPN	0:041:19:59:02.91	16
		LPE	0:041:19:59:02.91	16
CHTO	Chiang Mai, Thailand	SPZ(D)	9:332:17:34:45.32	16
		SPZ(N)	9:332:06:04:40.32	16
		LPZ	0:072:07:58:51.82	16
		LPN	0:072:07:58:51.82	16
		LPE	0:072:07:58:51.82	16
GRFO	Grafenburg, Germany	SPZ(D)	0:044:08:59:44.93	16
		SPZ(N)	0:043:23:59:55.93	16
		LPZ	0:044:02:54:54.93	16
		LPN	0:044:02:54:54.93	16
		LPE	0:044:02:54:54.93	16
GUMO	Guam, Mariana Islands	SPZ	0:032:05:59:44.14	16
		LPZ	0:032:05:55:42.14	16
		LPN	0:032:05:55:42.14	16
		LPE	0:032:05:55:42.14	16
MAIO	Mashhad, Iran	SPZ(D)	6:017:03:59:52.63	16
		SPZ(N)	6:016:23:04:31.63	16
		LPZ	8:182:12:55:15.15	16
		LPN	8:182:12:55:15.15	16
		LPE	8:182:12:55:15.15	16
NWAO	Narrogin, W. Australia	SPZ	0:040:03:59:16.92	16
		LPZ	0:040:03:57:26.92	16
		LPN	0:040:03:57:26.92	16
		LPE	0:040:03:57:26.92	16

Table 1.--Starting time of intervals selected for analysis. D indicates a daytime sample; N indicates a nighttime sample.

Station Code	Station Location	Component	Start Time (y:d:h:m:s)	Number Segments
SHIO	Shillong, India	SPZ(D)	0:048:06:45:14.30	16
		SPZ(N)	0:048:21:00:46.26	16
		LPZ	0:048:06:58:30.30	16
		LPN	0:048:06:58:30.30	16
		LPE	0:048:06:58:30.30	16
SNZO	South Karori, New Zealand	SPZ	0:044:02:59:53.93	16
		LPZ	0:044:00:56:32.93	16
		LPN	0:044:00:56:32.93	16
		LPE	0:044:00:56:32.93	16
TATO	Taipei, Taiwan	SPZ	0:052:11:59:23.91	16
		LPZ	8:336:00:05:49.91	10
		LPN	8:336:00:05:49.91	10
		LPE	8:336:00:05:49.91	10
ASRO STATIONS:				
CTAO	Charters Towers, Australia	SPZ	0:040:02:59:41.58	16
		LPZ	0:048:06:25:27.57	16
		LPN	0:048:06:25:27.57	16
		LPE	0:048:06:25:27.57	16
KAAO	Kabul, Afghanistan	SPZ	0:048:21:44:26.55	16
		LPZ	0:033:00:10:05.59	15
		LPN	0:033:00:10:05.59	10
		LPE	0:036:15:48:05.59	13
KONO	Kongsberg, Norway	SPZ	0:043:00:59:17.47	16
		LPZ	0:042:00:09:59.47	16
		LPN	0:042:00:09:59.47	16
		LPE	0:042:00:09:59.47	16
MAJO	Matsushiro, Japan	SPZ	0:068:02:04:12.38	16
		LPZ	0:015:11:55:33.51	16
		LPN	0:015:16:08:33.51	10
		LPE	0:015:10:55:03.51	14
ZOBO	Zongo Valley, Bolivia	SPZ	0:049:22:00:49.13	16
		LPZ	0:053:09:56:41.80	9
		LPN	0:053:09:56:41.80	9
		LPE	0:053:09:56:41.80	9

Table 1.--Starting time of intervals selected for analysis continued.

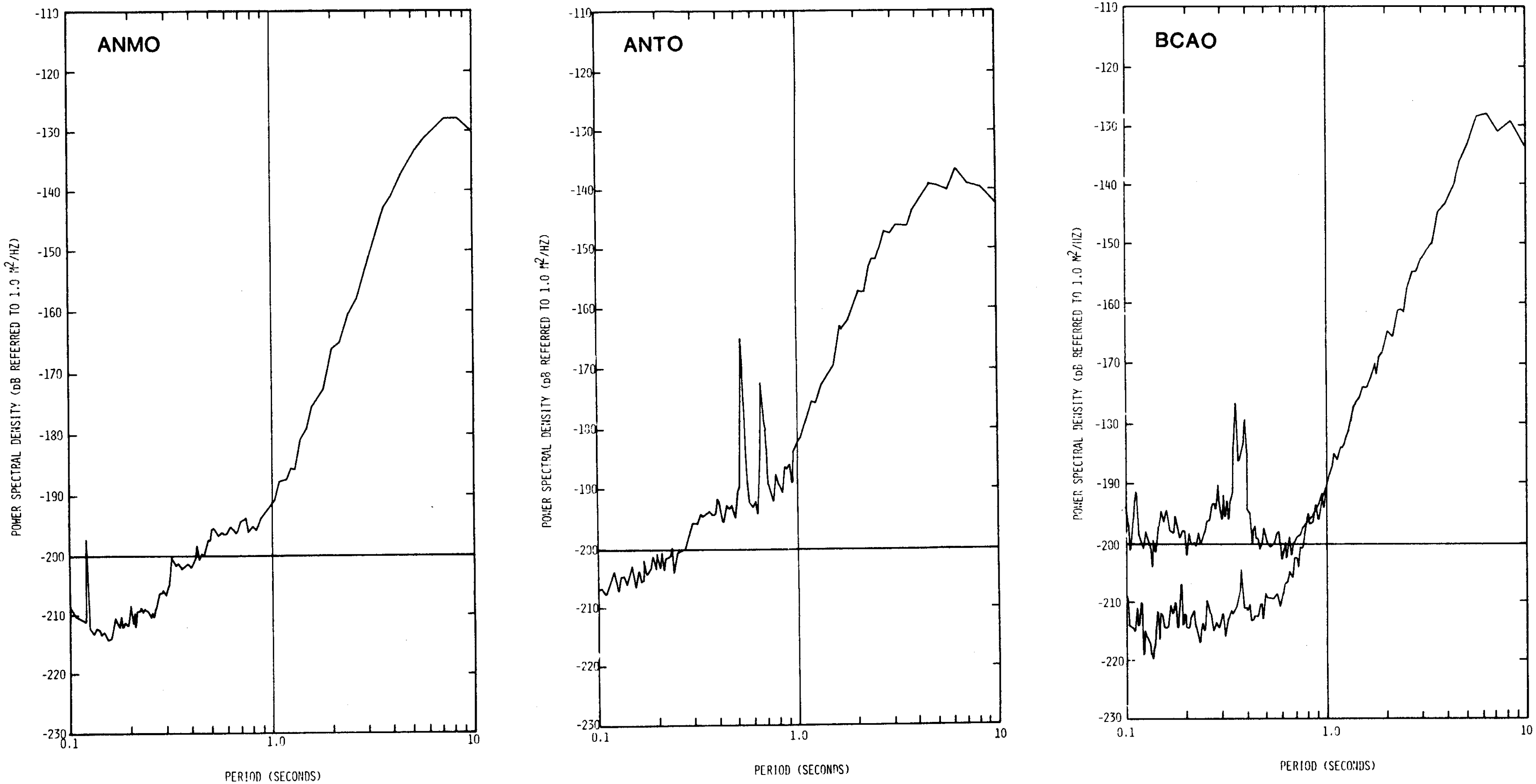

Figure 1.--Short-period background noise at SRO stations located near Albuquerque, New Mexico, Ankara, Turkey, and Bangui, Central African Republic. Where two levels are shown, the upper trace represents a daytime sample and the lower trace represents a nighttime sample.

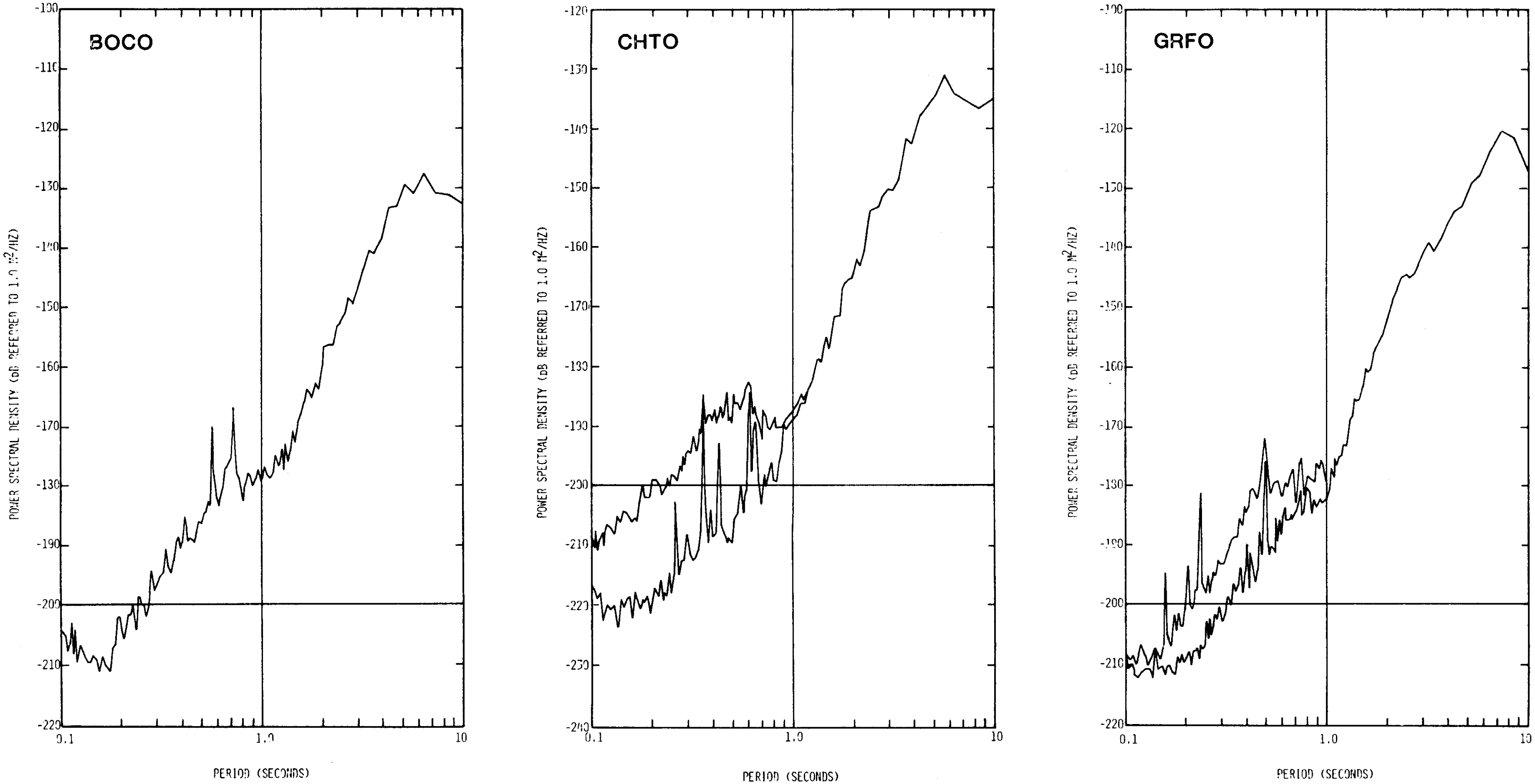

Figure 2.--Short-period background noise at SRO stations located near Bogota, Columbia, Chiang Mai, Thailand, and Grafenburg, Germany. Where two levels are shown, the upper trace represents a daytime sample and the lower trace represents a nighttime sample.

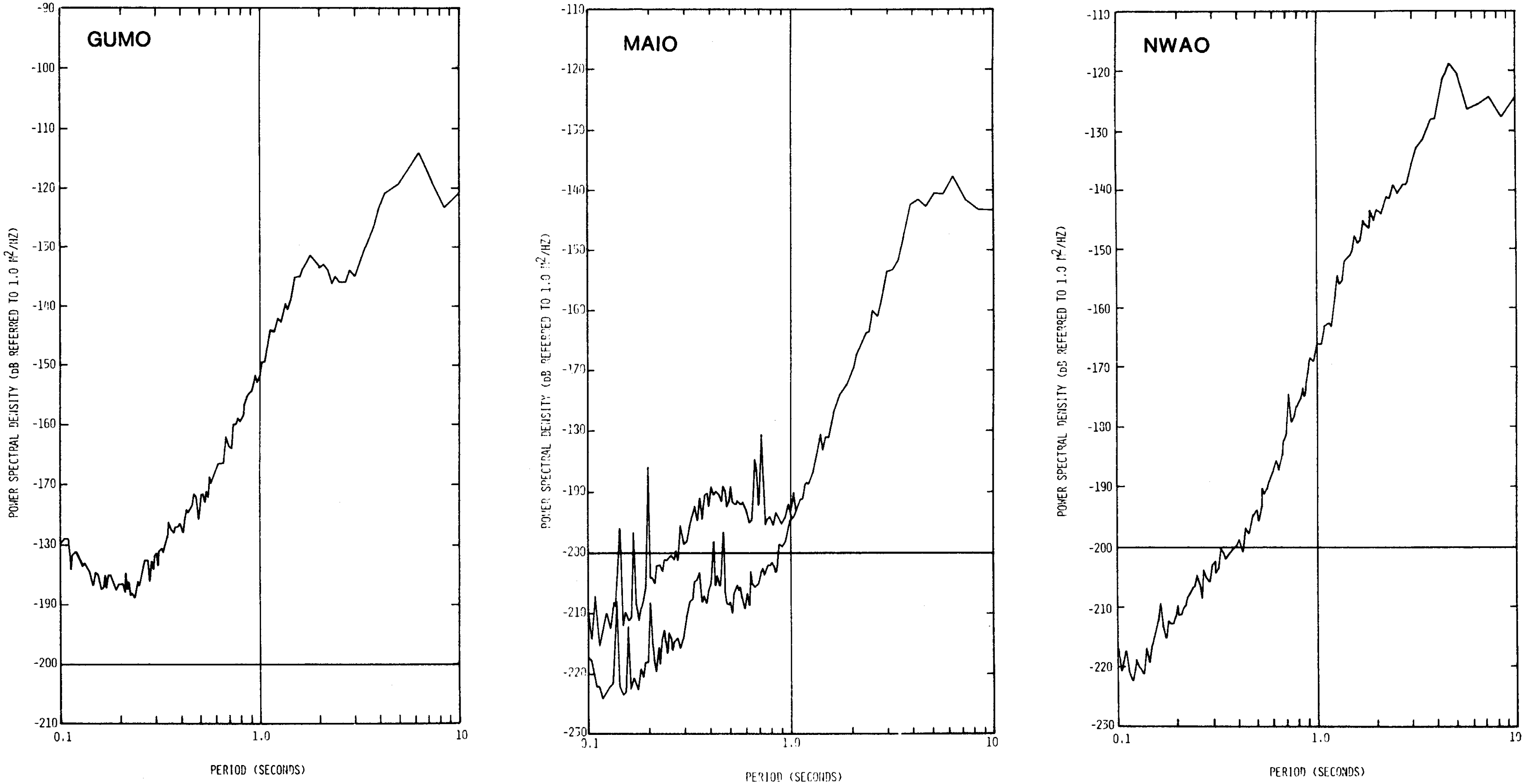

Figure 3.--Short-period background noise at SRO stations located at Guam and near Mashhad, Iran and Narrogin, Australia. Where two levels are shown, the upper trace represents a daytime sample and the lower trace represents a nighttime sample.

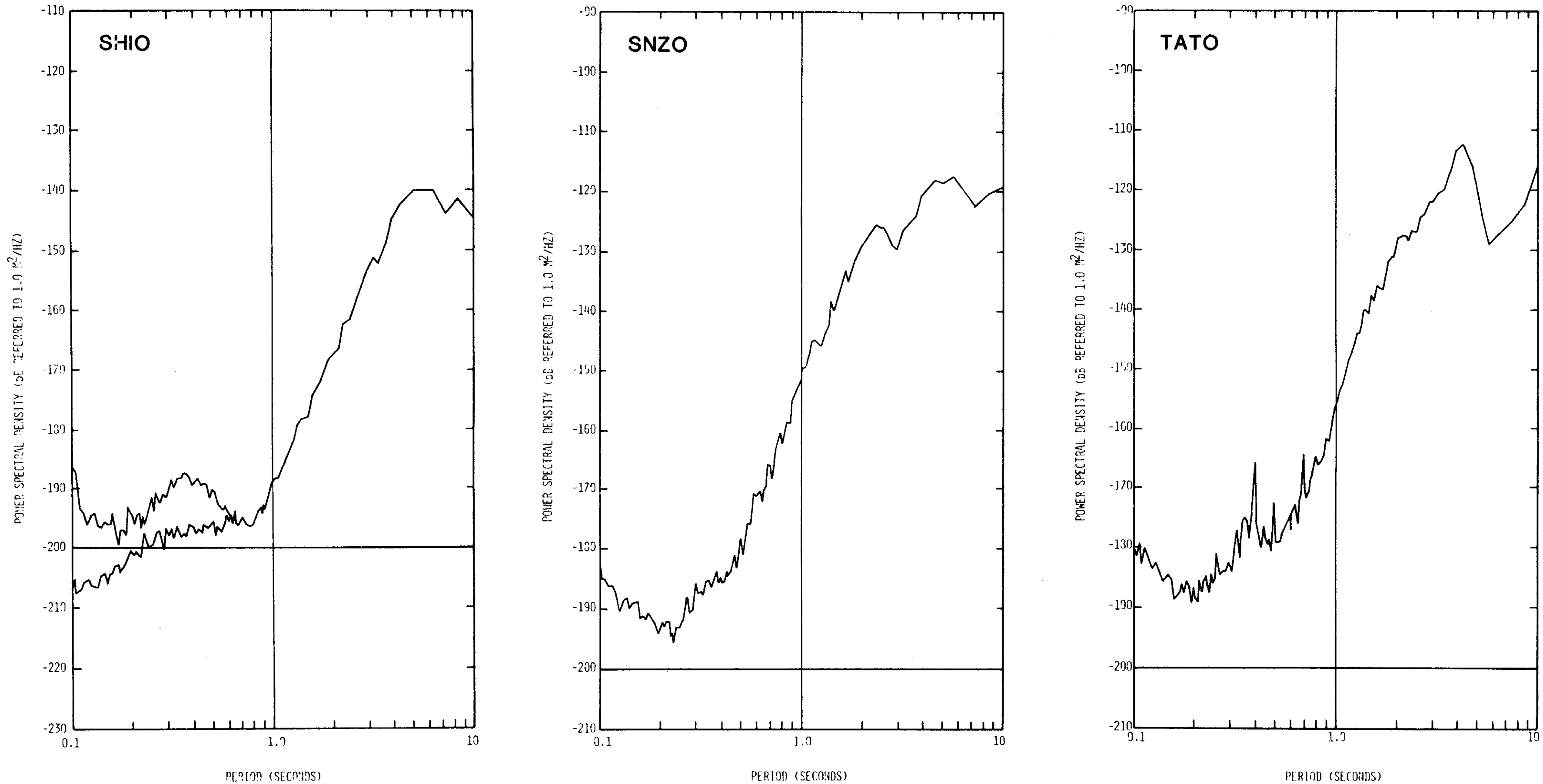

Figure 4.--Short-period background noise at SRO stations located near Shillong, India, South Karori, New Zealand, and Taipei, Taiwan. Where two levels are shown, the upper trace represents a daytime sample and the lower trace represents a nighttime sample.

1 second. The sharp spectral peaks appear to be cultural in origin. In cases where spectral data have been computed for several different intervals of time, the peaks are observed to vary in amplitude and sometimes disappear. In the case of ANMO, for example, there is a relatively persistent spectral peak at 0.22 seconds although it does not appear in this particular data sample. The ANMO spectral peak at .125 seconds is believed to be an aliased signal reflected from a sharp peak at .08 seconds that others have observed in the vicinity of the ANMO SRO station (H.B. Durham, personal commun., 1980). It too disappears on occasion. Short-period RMS noise amplitudes were computed for each station in the spectral interval from .2 to 2 seconds and these are shown in Figure 5. For reference, an earthquake-plus-noise signal is shown as well. RMS noise levels are computed from the spectral data after correction for instrument response.

Long-period power spectral densities computed from SRO station data are shown in Figures 6 through 9. Instrumental noise pulses that occasionally appear in the long-period data were avoided in selecting the data intervals for analysis. As Murphy and others (1972) concluded from their observations of high-gain long-period station data, the variation in long-period noise from site to site is far less than the variation of short-period noise. In fact, the maximum variation in noise power in the 20- to 40-second period band at the SRO stations is only about 10 dB. When anomalous values of noise are observed, instrumental causes should be suspected. The seismometer at BCAO for example, with its high levels of horizontal-component noise, is known to be defective because of shipping damage and is scheduled for replacement. The vertical components at GRFO, BOCO, and NWAO also have higher-than-average levels of long-period noise. On the other hand, the fact that the horizontal-component noise levels, although high, track closely together at SNZO might indicate an environmental noise source such as wind. The relatively high horizontal-component noise levels at GUMO are probably to be expected considering that this is a small island site. Long-period

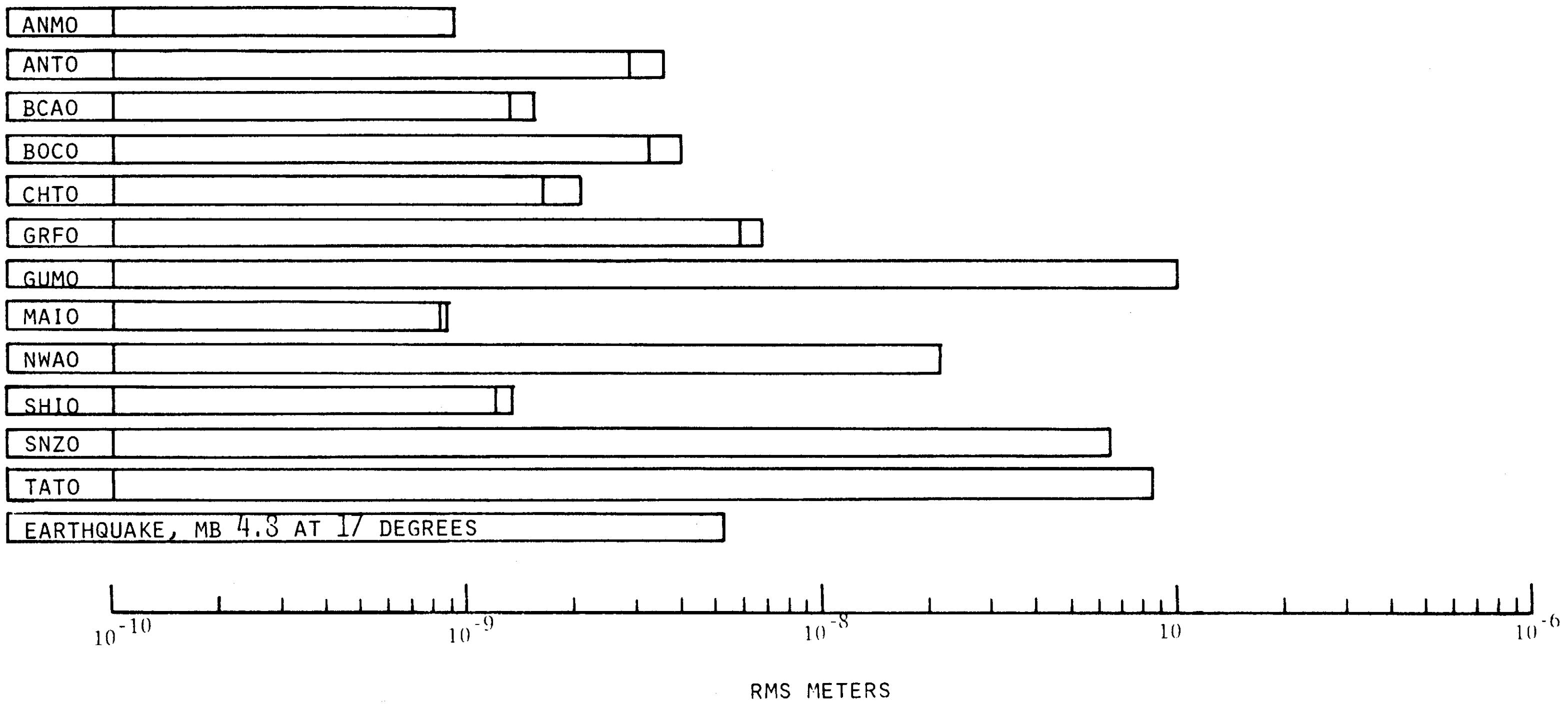

Figure 5.--RMS noise amplitudes at the SRO stations in the .2- to 2-second period band. Where two levels are shown, the higher level is for a daytime interval and the lower level is for a nighttime interval.

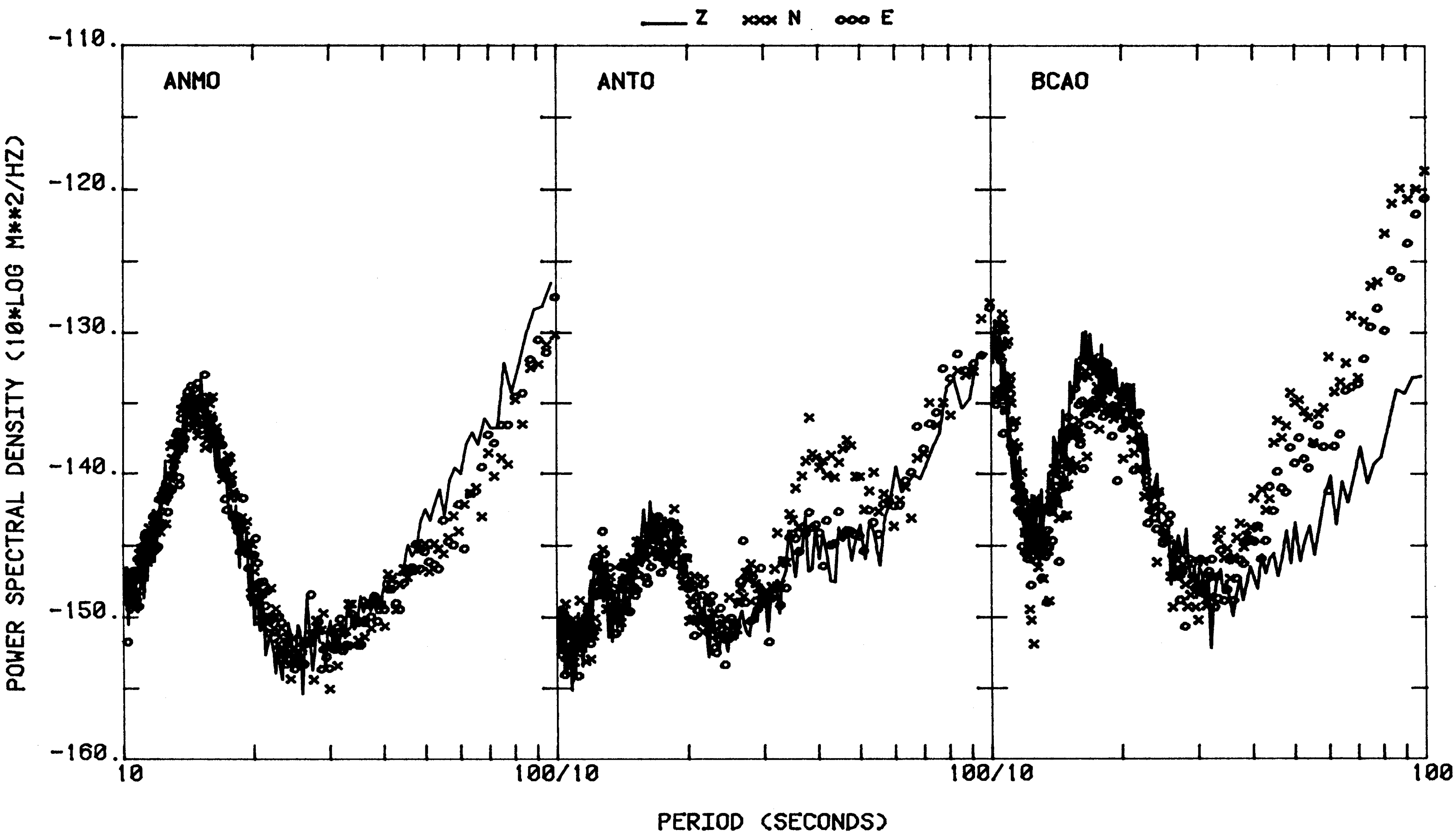

Figure 6.--Long-period background noise at SRO stations located near Albuquerque, new Mexico, Ankara, Turkey, and Bangui, Central African Republic.

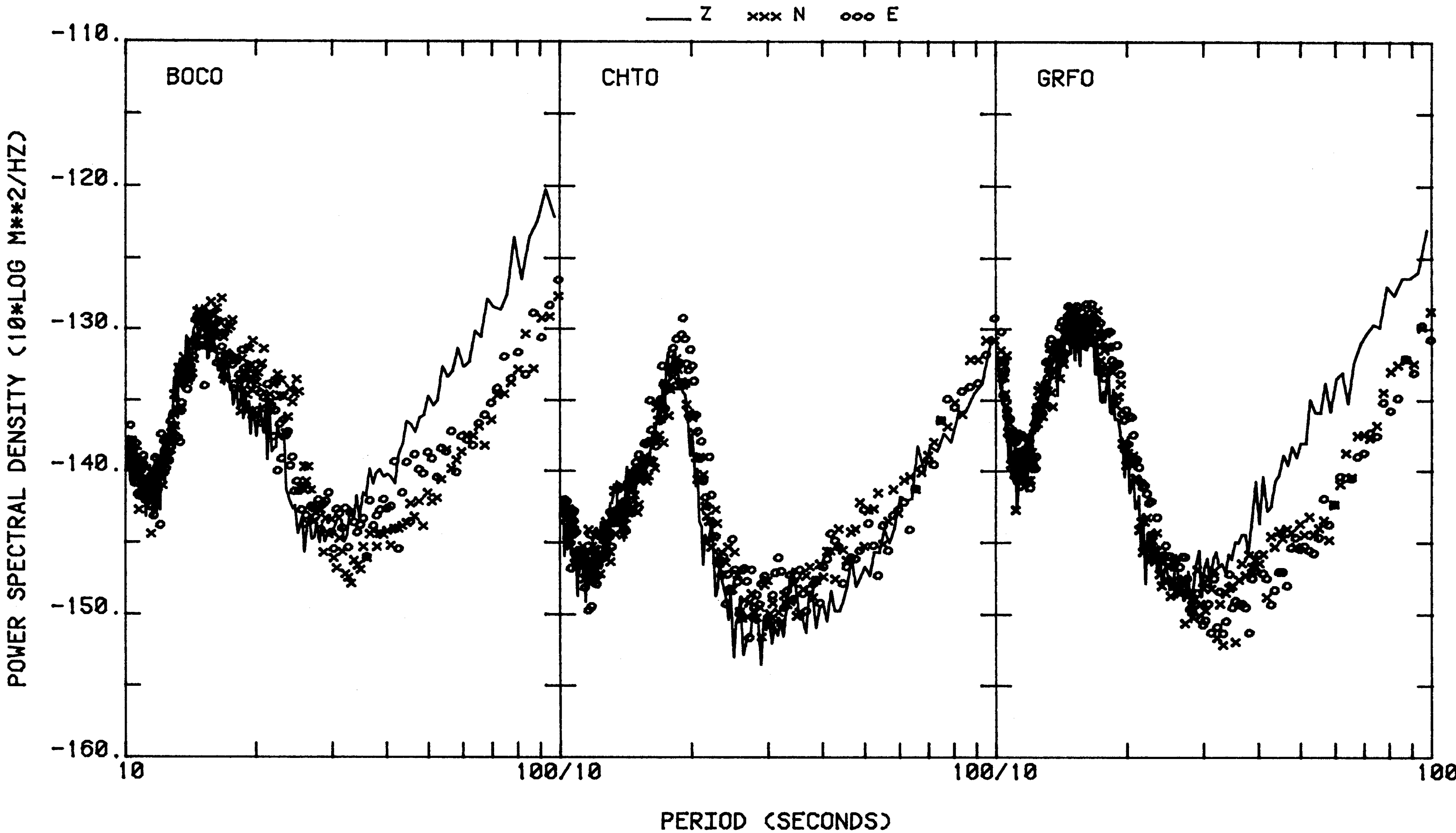

Figure 7.--Long-period background noise at SRO stations located near Bogota, Columbia, Chiang Mai, Thailand, and Grafenburg, Germany.

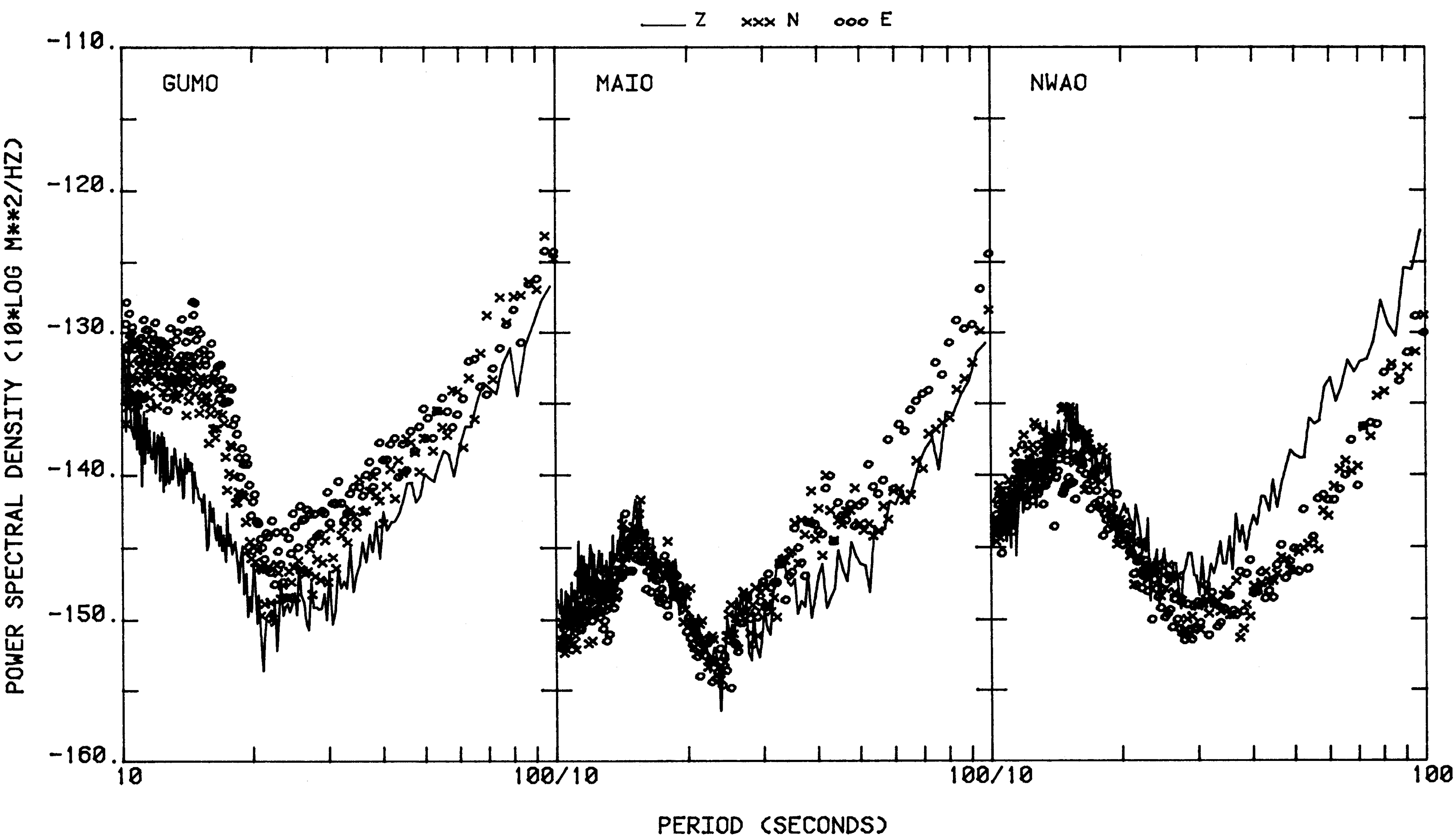

Figure 8.--Long-period background noise at SRO stations located at Guam, Mashhad, Iran, and Narrogin, Australia.

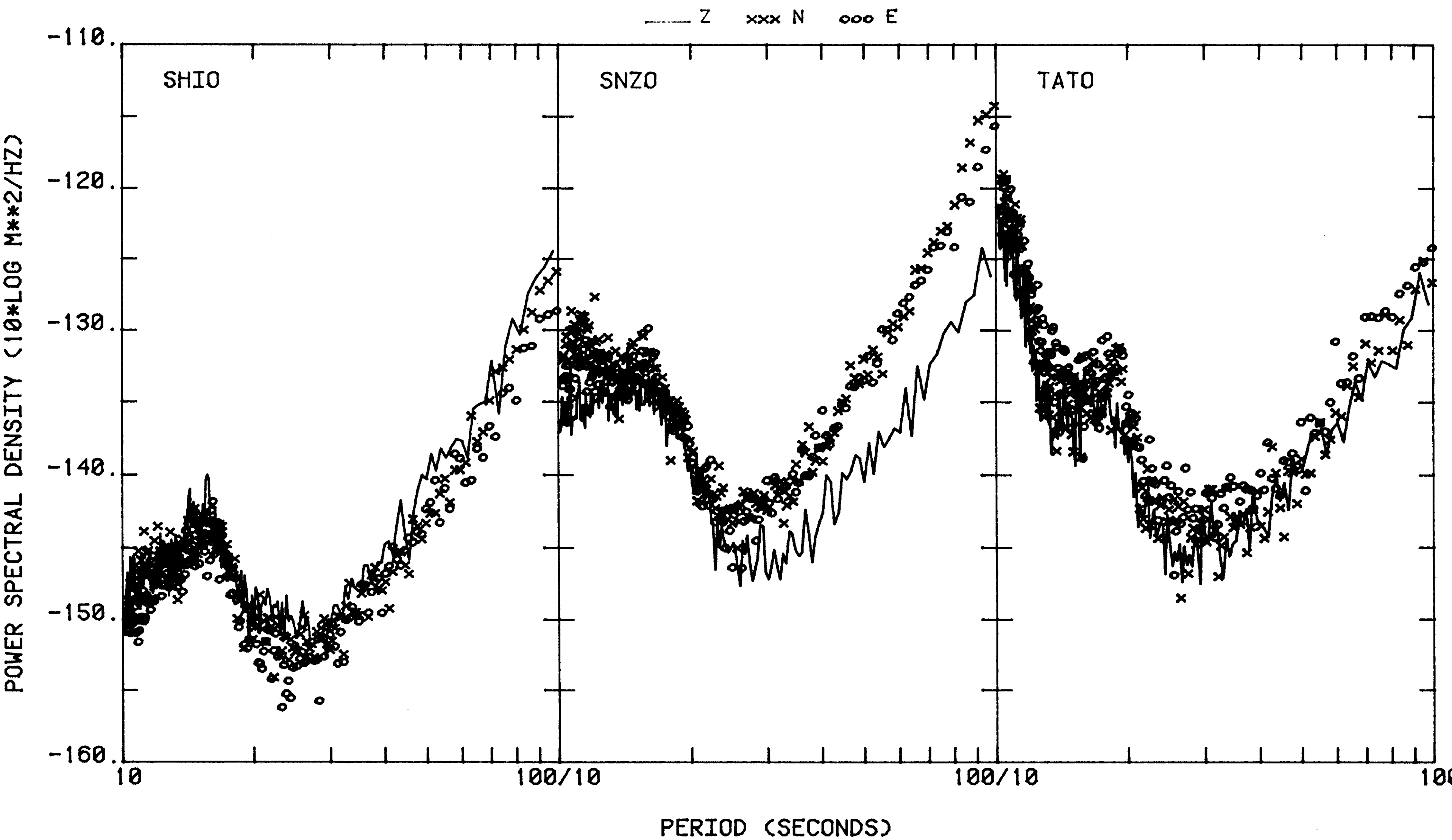

Figure 9.--Long-period background noise at SRO stations located near Shillong, India, South Karori, New Zealand, and Taipei, Taiwan.

RMS noise amplitudes are shown in Figure 10. Values are given for the 10- to 100-second period band and the 20- to 40-second period band. The RMS amplitude of an earthquake-plus-noise signal is shown for comparison.

ASRO DATA

The ASRO systems differ from the SRO systems in that short- and long-period signals are derived from separate conventional seismometers rather than from broadband borehole sensors. The operating environment is not as well controlled although the long-period seismometers are installed in pressure-tight tanks. Short-period noise spectra obtained from ASRO station data are shown in Figures 11 and 12. There are no discernible differences between ASRO and SRO short-period spectra that could be attributed to differences between the two types of instruments or their operating environment. RMS noise amplitudes are shown in Figure 13.

ASRO long-period noise spectra are shown in Figures 14 and 15, and the associated RMS amplitudes are shown in Figure 16. In general, it is apparent that during quiet, windfree periods the ASRO-station data are as quiet as the SRO-station data. However, during windy periods, the near-surface stations (KAAO, CTAO, and MAJO) can be expected to show a dramatic increase in long-period noise.

COMPOSITE LOW-NOISE DATA

A composite low-noise curve, shown in Figure 17, was obtained by overlaying spectral plots and selecting low-noise points while ignoring narrow spectral peaks and valleys. Cultural noise in the .1- to 1-second period band is more or less averaged out in the process so the composite curve is probably a fair representation of noise levels that could be expected at isolated sites in quiet regions of the world using SRO- or ASRO-type instruments. Its construction is useful in providing design criteria for seismic instruments that are intended for maximum signal resolution. The x's shown

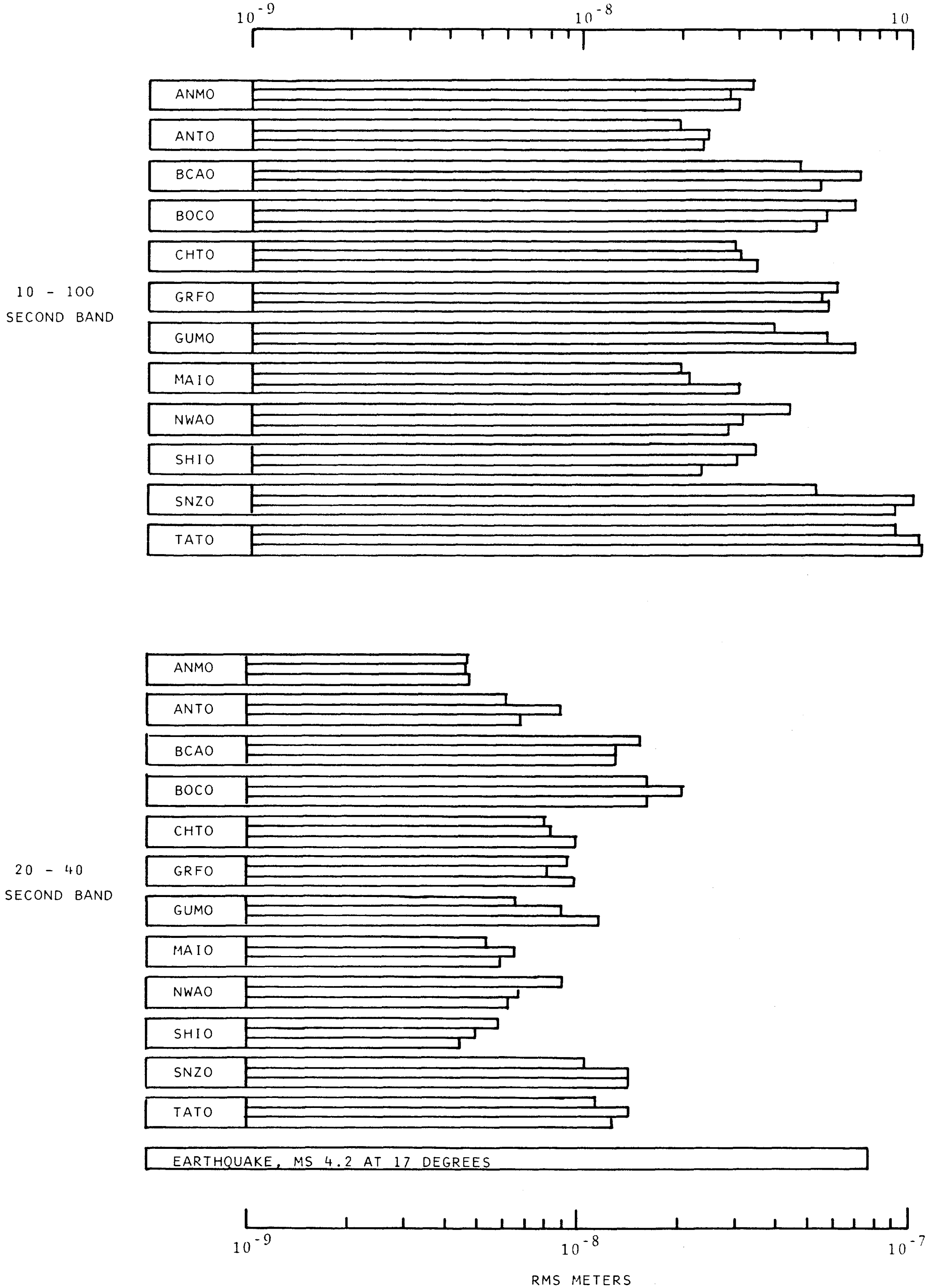

Figure 10.--RMS noise amplitudes at the SRO stations for two spectral bands. Top, middle, and lower bars represent vertical, north, and east components respectively.

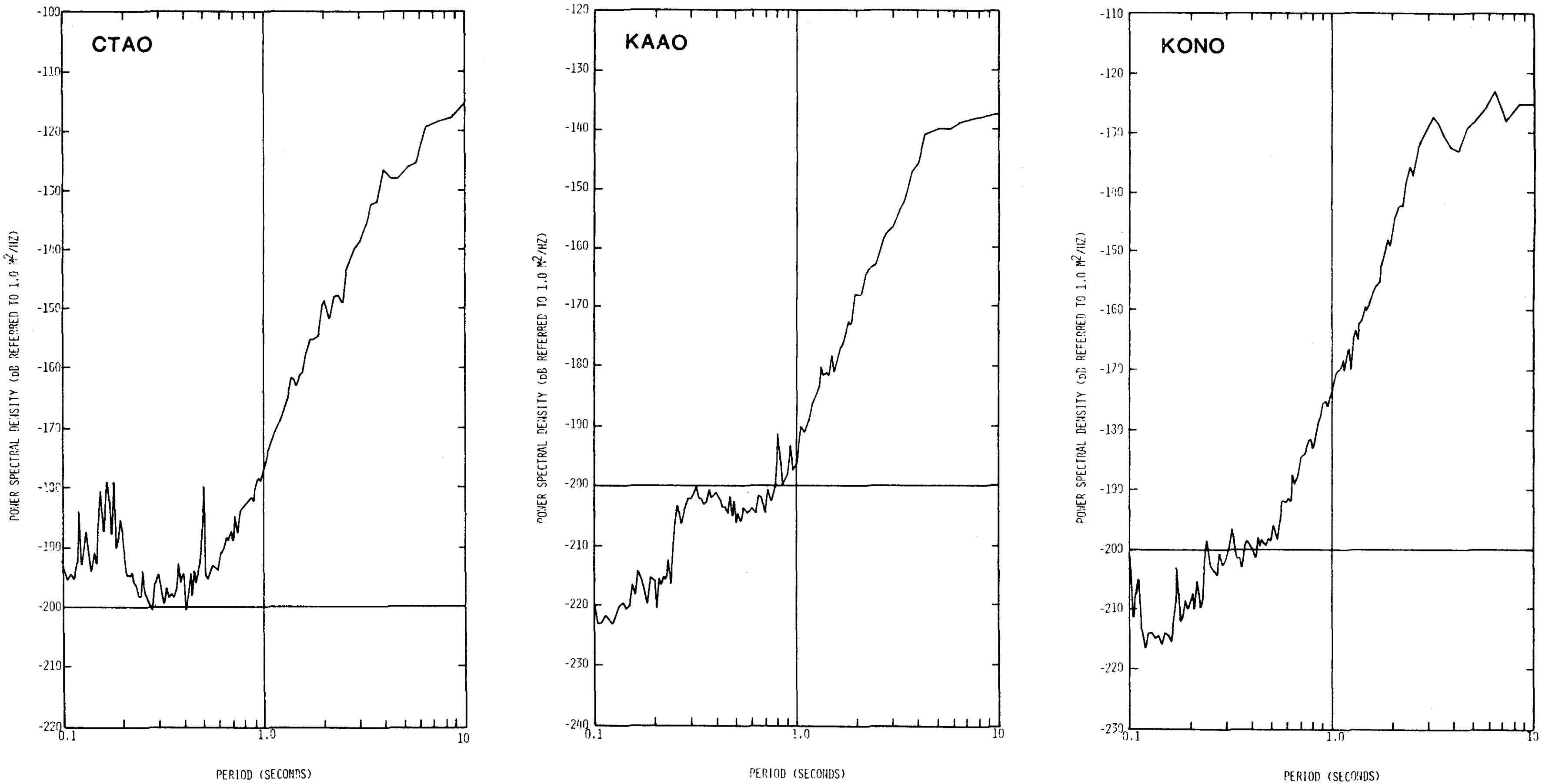

Figure 11.--Short-period background noise at ASRO stations located near Charters Towers, Australia, Kabul, Afghanistan, and Kongsberg, Norway.

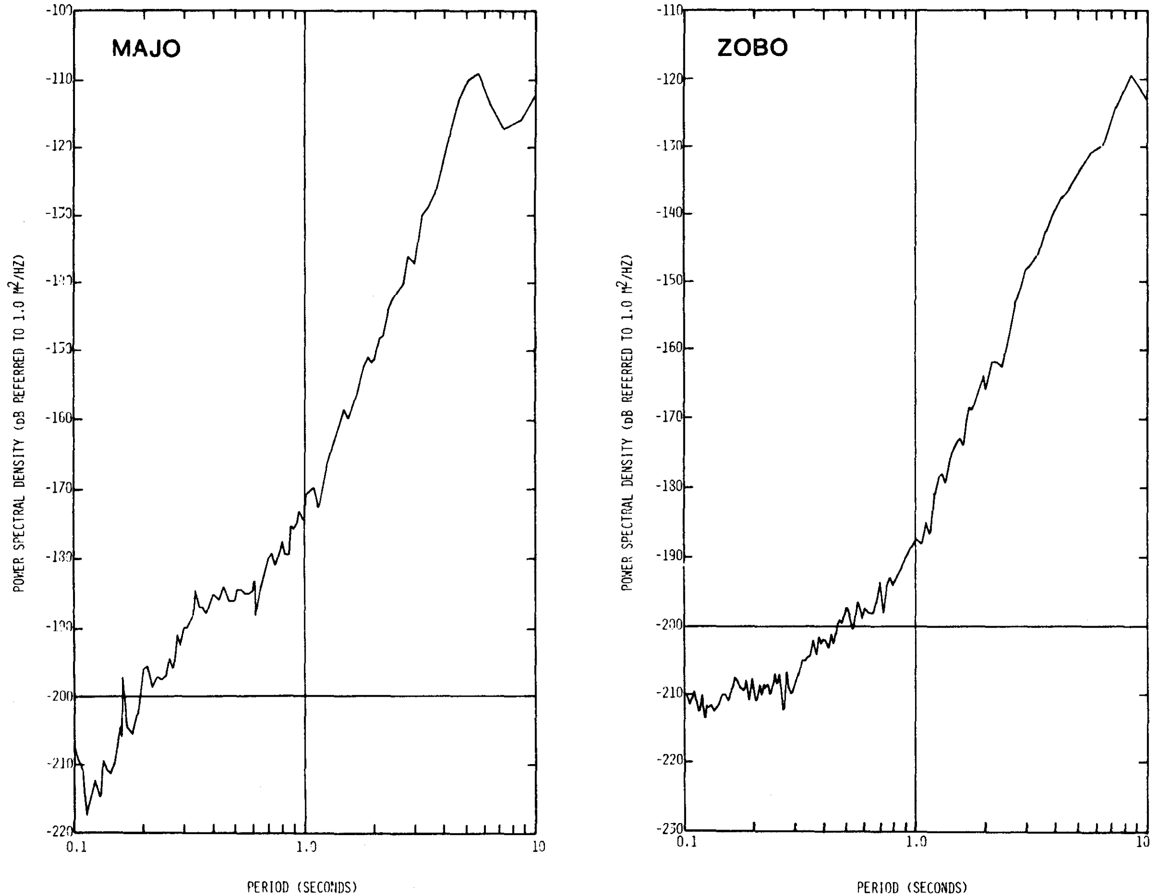

Figure 12.--Short-period background noise at ASRO stations located near Matsushiro, Japan and Zongo Valley, Bolivia.

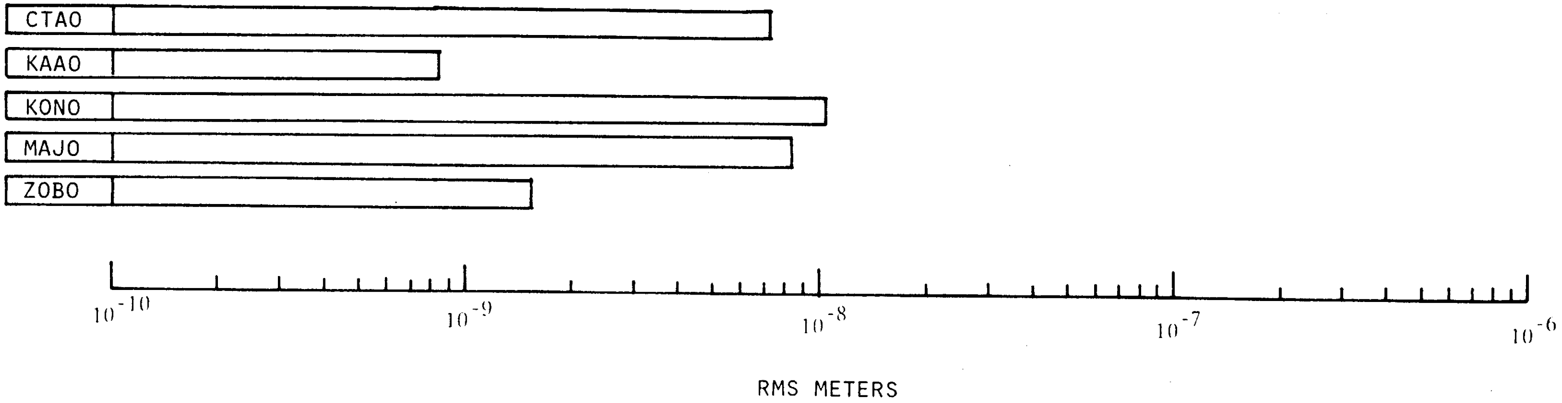

Figure 13.--RMS noise amplitudes at the ASRO stations in the .2 to 2 second band.

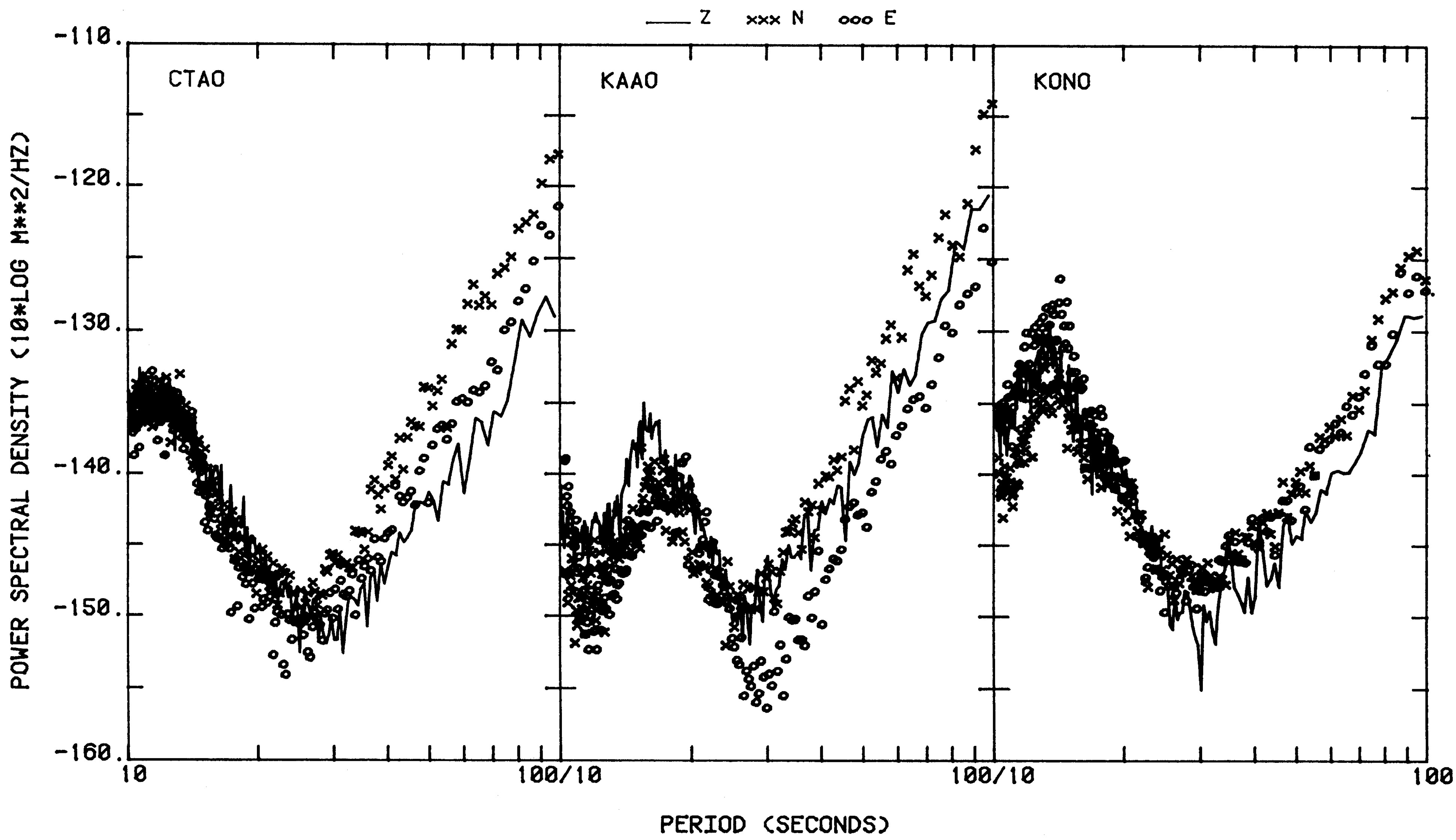

Figure 14.--Long-period bakcground noise at the ASRO stations located near Charters Towers, Australia, Kabul, Afghanistan, and Kongsberg, Norway.

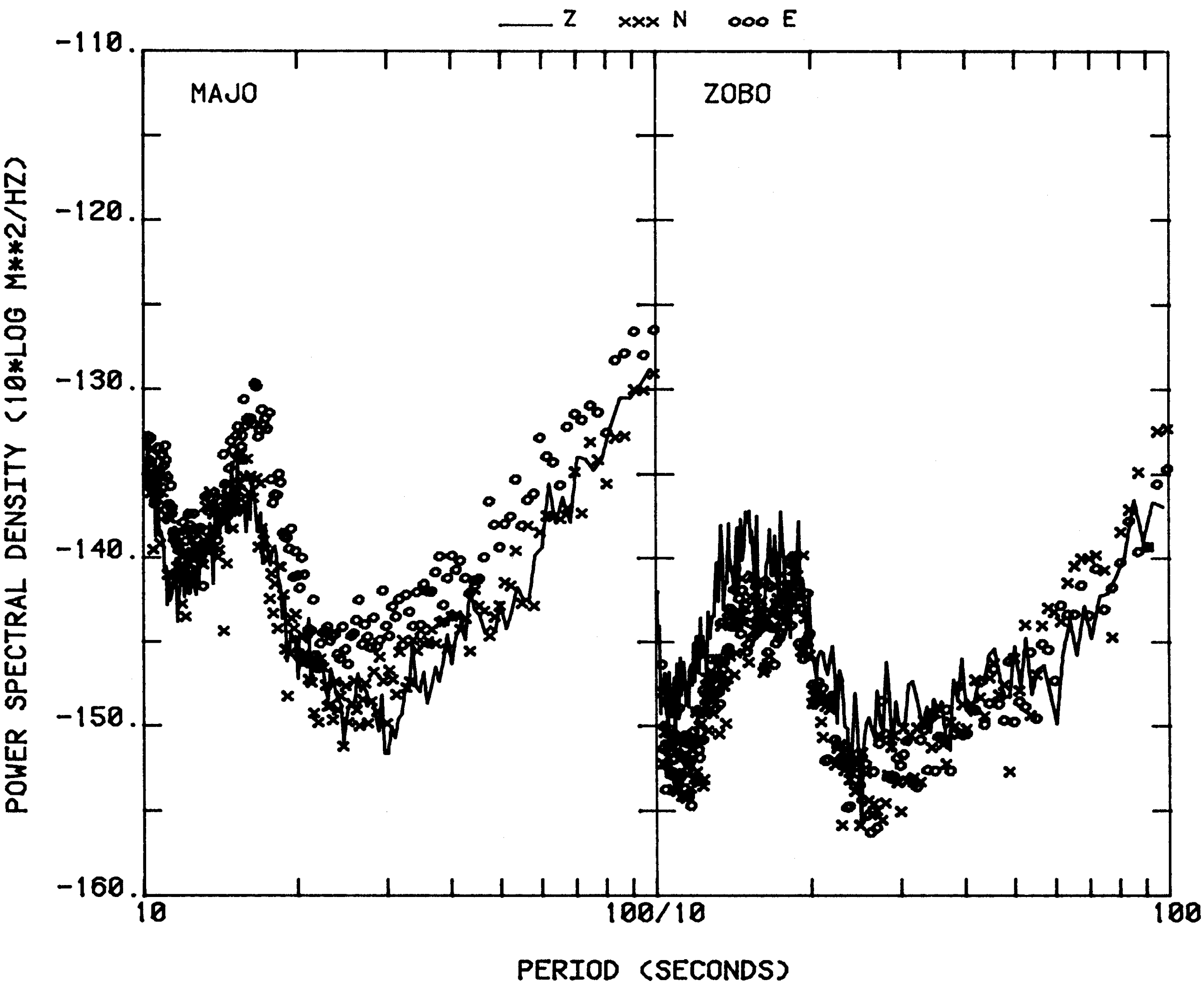

Figure 15.--Long-period background noise at the ASRO stations located at Matsushiro, Japan and Zongo Valley, Bolivia.

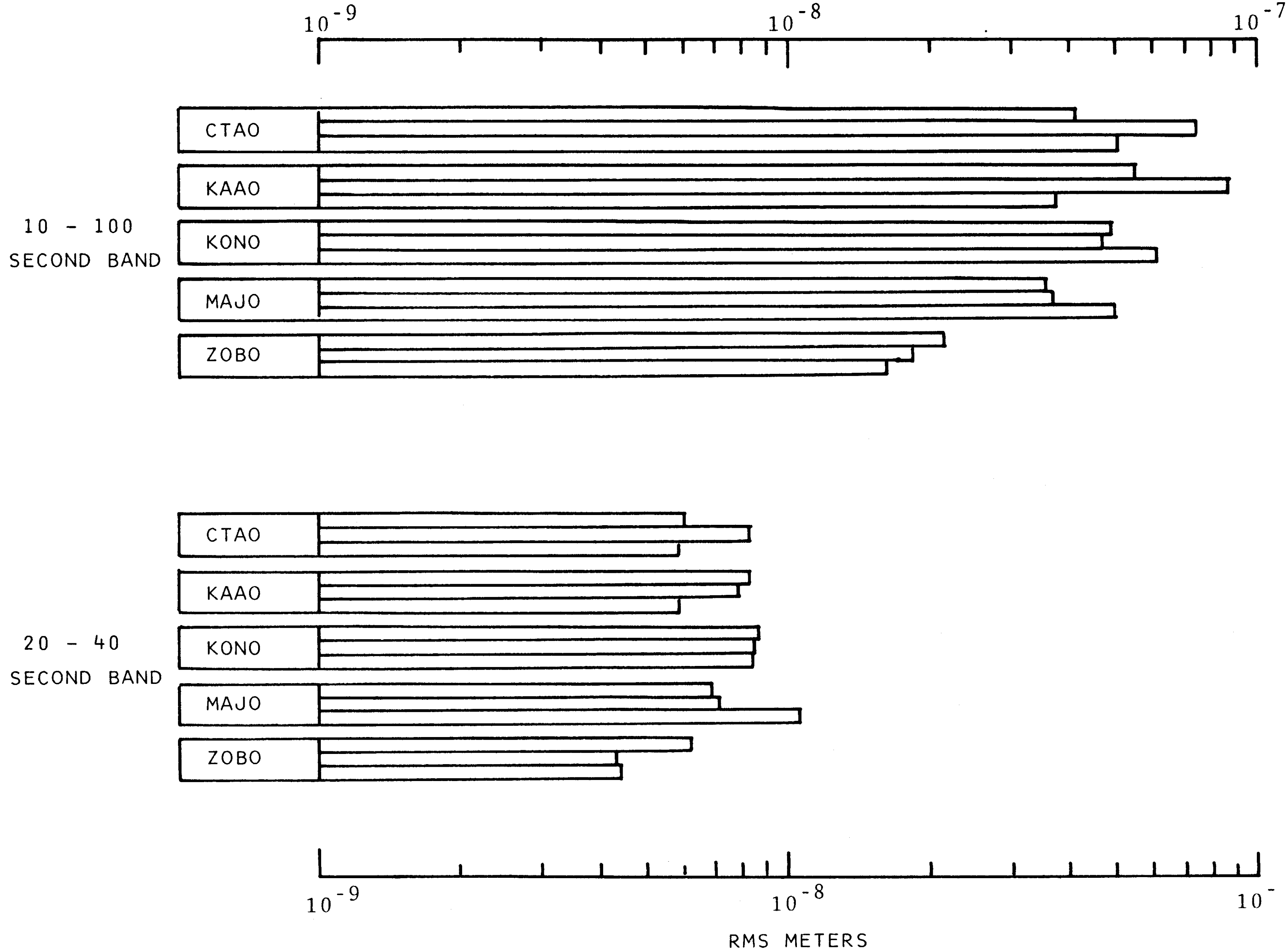

Figure 16.--RMS noise amplitudes at the ASRO stations for two spectral bands. Top, middle, and lower bars represent vertical, north, and east components respectively.

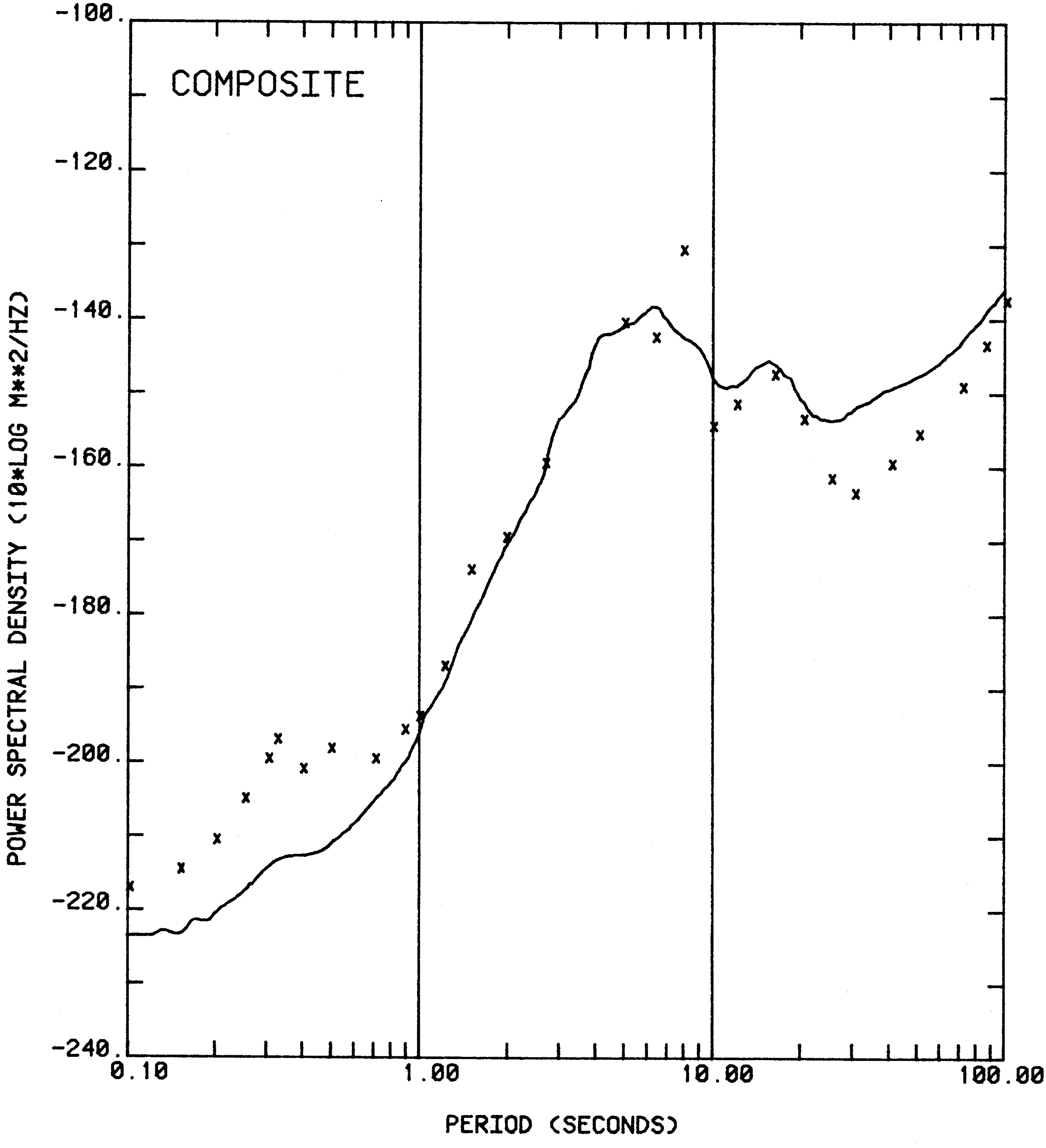

Figure 17.--A composite noise curve obtained by combining low noise points of the SRO and ASRO noise data. The x's are points taken from Queen Creek noise data published by Fix (1972).

in the figure are points taken from Queen Creek, Arizona, spectral data published by Fix (1972). The Queen Creek data have often been used as a low-noise model. It is interesting that the quieter SRO and ASRO sites and the Queen Creek site all have noise power levels within a few dB of each other at 1 second, and indicate that it may be difficult to find lower noise levels at this period at any location in the world. The composite noise power is significantly lower than the Queen Creek noise power between .1 and 1 second. This is due principally to the contribution of low noise data from African and Asian stations. At periods above 20 seconds, the Queen Creek noise power is lower than the composite noise power. This may or may not be significant. Sherwin and Kraus (1974) pointed out that this particular sample of spectral data is not typical of the long-term observations made at Queen Creek. Their typical example of Queen Creek spectral data show the noise power to be similar to the composite curve. The low-noise curve presented here is certainly subject to refinement as additional data are analyzed or become available from other high-resolution digital-recording observatories.

ACKNOWLEDGEMENT

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