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A Survey of the Ambient Motion Environment in the Southwestern United States

HENRY A. OSSING
ROBERT A. GRAY

28 February 1978

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AIR FORCE GEOPHYSICS LABORATORY
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AIR FORCE SYSTEMS COMMAND, USAF

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FOR THE COMMANDER

John Howard

Chief Scientist

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An examination of published ambient motion data peculiar to the American Southwest is presented. Areas considered are within the Basin and Range physiographic province, namely Arizona, Nevada, and New Mexico. Ground intensity level determinations, formatted as displacement and acceleration, are compared with continental and world-wide averages. A characterization of the physical and theoretical nature of microseismic activity is included.

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1. INTRODUCTION

The Terrestrial Sciences Division of the Air Force Geophysics Laboratory (AFGL) has undertaken a survey of data that have been collected on the ambient motion environment in the southwestern United States. The survey consists of an examination of data, found in the scientific literature, on measurements of seismic background noise, or microseisms, in areas of the Southwest. Areas that were considered fall within the Basin and Range physiographic province and are located in the states of Arizona, Nevada, and New Mexico.

For the most part, reported data on ambient motions or microseismic intensities are based on measurements of ground velocity, since the instruments normally used for the measurements are velocity sensors. It is felt that for the purposes of this report, a more meaningful presentation of the data would be in terms of ground displacements and ground accelerations. Therefore, unit conversion of the data into this format has been made accordingly.

Displacement and acceleration spectra have been compiled from microseismic data taken from several independent sources. These data should only be considered in a stochastic, psuedo-stationary sense, as the sampled time frame for the best case is only several months, while other observations are limited to days or even hours. Hence, diurnal and secular periodicities are not necessarily considered.

(Received for publication 28 February 1978)

2. MICROSEISMS

2.1 Introductory Resume

Before considering the characteristic microseismic activity of the American Southwest, a brief summary is offered as to the theoretical aspects and physical nature of microseisms. The term "microseisms" means small elastic wave motions in the solid crust of the earth.[1] Microseisms often go by other designations such as seismic noise, earth/seismic background, etc. Their generation is due to external influences primarily from the atmosphere and the sea, and in general have no relation to earthquakes. Microseisms are ubiquitous, always present on seismic records to a varying degree of intensity. Two opposing theories are dominant as to the origin of microseisms; namely the coastal theory, which explains microseisms originating from surf or shoreline activity, and the cyclonic theory which ascribes the origin of microseisms to cyclonic activity over deep water. There exists sufficient evidence to the correctness of both theories. The observations made at any one station are seemingly predicated on the station's location relative to the coast; the more proximate the coast the more effects notable to surf activity. Further inland the effects become more traceable to cyclonic deep water activity.

The literature on microseisms peaked in the mid-sixties as a consequence of the government sponsored VELA-UNIFORM program.[2,3] Studies prior to this period were substandard attributed to the unfamiliarity of investigators with the complexities of the subject.

Microseisms can be considered as the continuous state of unrest within the earth's crust. Their characteristics are a function of both time and space, and simplistically can be divided into frequency dependent branches, namely:

(1) Long-period microseisms—periods > 10 seconds.

(2) Storm microseisms—periods from 2-10 seconds.

(3) Short-period microseisms—periods < 2 seconds.

Thus at a given station there is likely to be present a mixture of locally generated vibrations of short period, regionally generated vibrations of intermediate period, and long-period vibrations which may affect the entire earth.

Long-period microseisms, apart from earth-tide phenomena, commence at the longer periods with the spheroidal and torsional modes of the earth ranging in period from 300-3000 seconds. Below 300 sec the microseismic spectrum shows no dominant energy peaks until approaching 25 seconds. The 25-sec waves are attributed

1. Bath, M. (1973) Introduction to Seismology, John Wiley & Sons, New York.
2. VESIAC STAFF (Editor), (1962) Problems in Seismic Background Noise, VESIAC Advisory Report, 4410-32-X, University of Michigan.
3. Iyer, H. (1964) The History and Science of Microseisms, VESIAC Report No. 4410-64-X, University of Michigan.

to the coupling of cyclonic generated ocean waves with the sea bed at teleseismic distances, and are not to be confused with the storm microseismic branch. A second spectral peak is located near periods of 4-10 sec, located in what is termed the storm microseismic branch and a third peak in the short-period branch near 1-2 Hz. These peaks are well documented in the current literature as a result of earth noise surveys conducted under the ARPA sponsored Long Range Seismic Measurement (LRSM) program incorporating data gathered from the Large Aperture Seismic Array (LASA) network located in the state of Montana.

The LRSM survey provides frequency and amplitude levels at discrete points for North America and parts of Europe, delineating the predominant microseismic frequency for a given area and time frame. Of special note is the existence of a pronounced decrease in amplitude evident in the 30 - 40 sec band. This noise minimum appears to be global in character exhibiting stable spatial and temporal characteristics.[4,5]

Much literature has been published with reference to the storm microseismic band. There are a number of reasons for this emphasis; the prevailing one being that microseismic activity having periods between 4-10 sec are comparatively large in amplitude and lie in the middle of the teleseismic band. The occurrences of high levels of activity have been well correlated with meteorological and surf conditions. As a rule, there is a pronounced increase in storm microseismic amplitude in winter. These increases in the level of activity may last from a few hours to several days. During these active periods, seismograms from coastal observatories are all but unreadable. These storms of microseismic activity are often associated with deep low pressure areas and frontal passages impinging on the continental margins. Their mode of propagation approaches the Rayleigh surface wave mode traveling at a velocity of approximately 2.7 km/second.[3] They travel with little attenuation over oceanic and continental paths but suffer a rapid attenuation from one path to the other. The amplitudes decrease with distance from the coast and are sharply attenuated at mountainous boundaries. The American Southwest, because of its proximity to the Pacific Ocean, is inclined to this type of earth noise environment; therefore, it would not be too presumptuous to predict that the storm microseismic band significantly contributes to the ambient levels observed in this part of the country.

The short-period microseismic band is source varied associated with cultural activity, localized wind action, and natural phenomena such as rivers, geothermal, etc. The frequency level peaks near 1 Hz and is noted for its rapid attenuation having both body wave and modal surface wave propagating characteristics.

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4. Geotech Technical Report 63-45, (1963) Seismic Noise Survey, Volume 1.
5. Geotech Technical Report 65-25, (1965) Seismic Noise Survey, Volume 2.

A brief summary compiled by Gutenberg presenting the total microseismic band as a function of causative source follows.[6]

Period (sec)	Hypothetical cause
0.001-0.5	Traffic, industry wind
0.2-2	Surf
1-4	Frosts, turbulent wind
1-4	Effects of wind on trees, buildings
2-6	Ocean waves in hurricanes, typhoons
4-10	Ocean waves in extratropical disturbances
4-10	Surf driven by wind against steep coasts
4-10	Air pressure pulsations?
4-10	Monsoon and similar types of wind
10-20	Water waves striking the coast
20-100	Wind? Air currents in instrument vaults?
40-100	Freezing of ground? "Icing" of instruments.

2.2 Southwest Physiography and Microseismic Motion

The Basin and Range Physiographic Province boundaries encompass all of Nevada, major portions of Utah, and Arizona, and portions of New Mexico, California, and Idaho (Figure 1). Tectonically, the Basin and Range structure has myriad but no simple explanation.[7, 8, 9] The hypotheses range from convective cell extensions to mantle diapir (pierce folding) processes associated with plate subduction. What is most evident is that the province is undergoing crustal extension that it is highly faulted, but paradoxically having low seismicity. What can generally be said is that in terms of plate tectonics the Basin and Range Province is presently exhibiting subplate characteristics bounded by high seismicity belts, for example, San Andreas, Wasatch, etc.[10]

6. Gutenberg, B. (1958) Microseisms, Advances in Geophysics, Vol. 5, Academic Press, New York.

7. Smith, R., and Sbar, M. (1974) Contemporary tectonics and seismocity of the western United States with emphasis on the Intern-Mountain Seismic Belt, Bull. Geol. Soc. Amer. 85:1205-1218.

8. Schulz, C., and Barazangi, M. (1971) Late cenozoic evolution of the Great Basin western United States as an ensialic interarc basin, Bull. Geol. Soc. Amer. 82:2979-2990.

9. Thompson, G., and Burke, D. (1974) Regional geophysics of the Basin and Range Province, Annual Review of Earth and Planetary Sciences, pp 213-238.

10. Walper, J. (1976) State of the Art for Assessing Earthquake Hazards in the United States, Miscellaneous Paper S-73-1, Report No. 5, AD A023967.

Intra Basin and Range microseismic activity reflects the lowest equivalent motions in terms of displacement, particle velocity, and equivalent acceleration.[11,12] This region shows limited effects of proximity to coast line, vegetation, and population. For comparison purposes Figures 1 and 2 delineate physiographic average microseismic activity in terms of displacement and particle velocity respectively. As is most evident, the Basin and Range Province is several factors lower in intensity than the majority of the other continental provinces. The same can be said for motions in terms of equivalent acceleration, Figure 3. Here, the equivalent acceleration at the 1 Hz level is in good agreement with Frantti's and the LRSM station data measurements used in this survey summary.

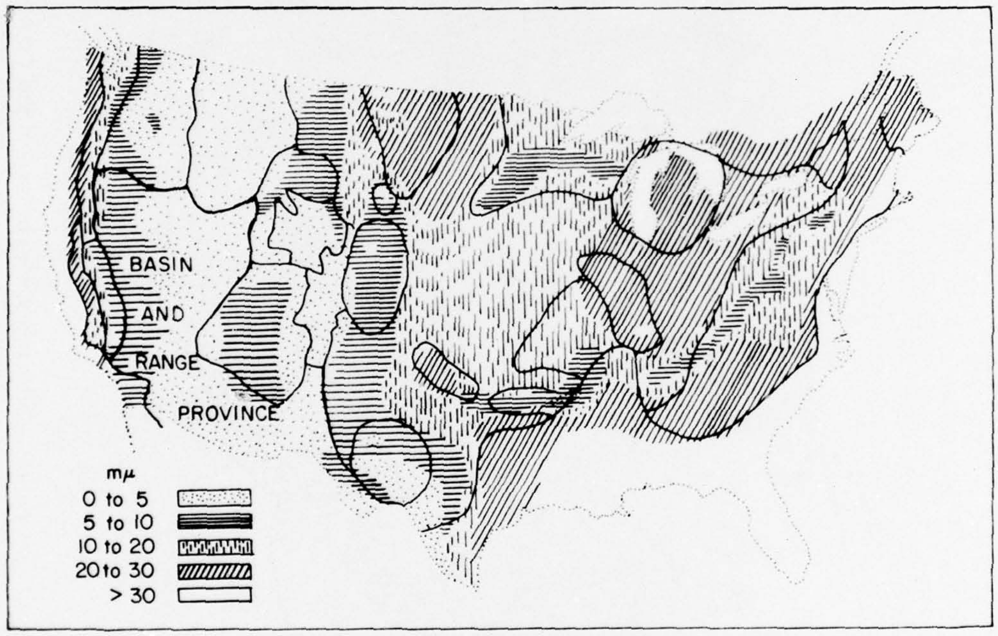

Figure 1. Average Background Noise 0.3-1.4 Seconds (displacement)

11. Frantti, G. (1965) Investigation of Short-Period Noise in Major Physiographic Environments of Continental United States, AFCRL-65-406.
12. Alsup, S. (1963) Preliminary Study of Acceleration Levels at LRSM Sites, Geotech Technical Report No. 63-49.

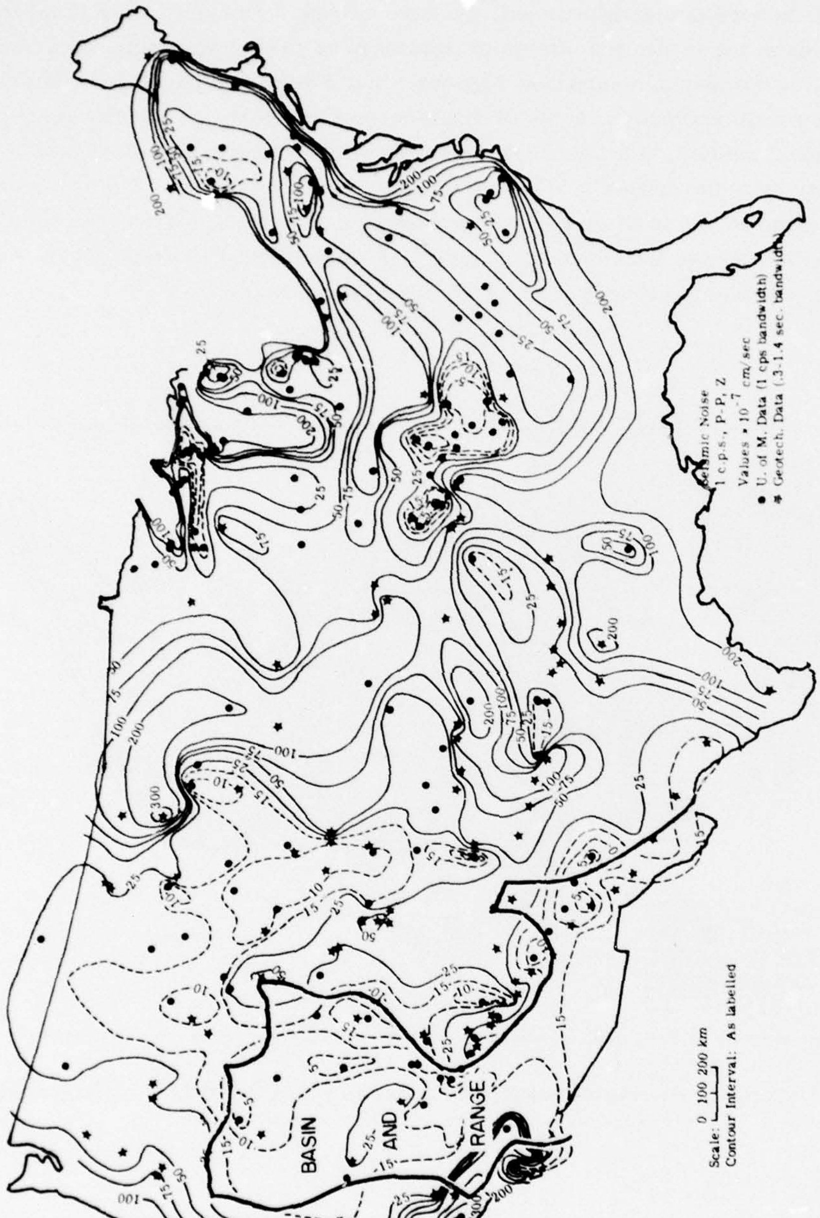

Figure 2. Iso-Particle-Velocity Contour Map of the Continental United States

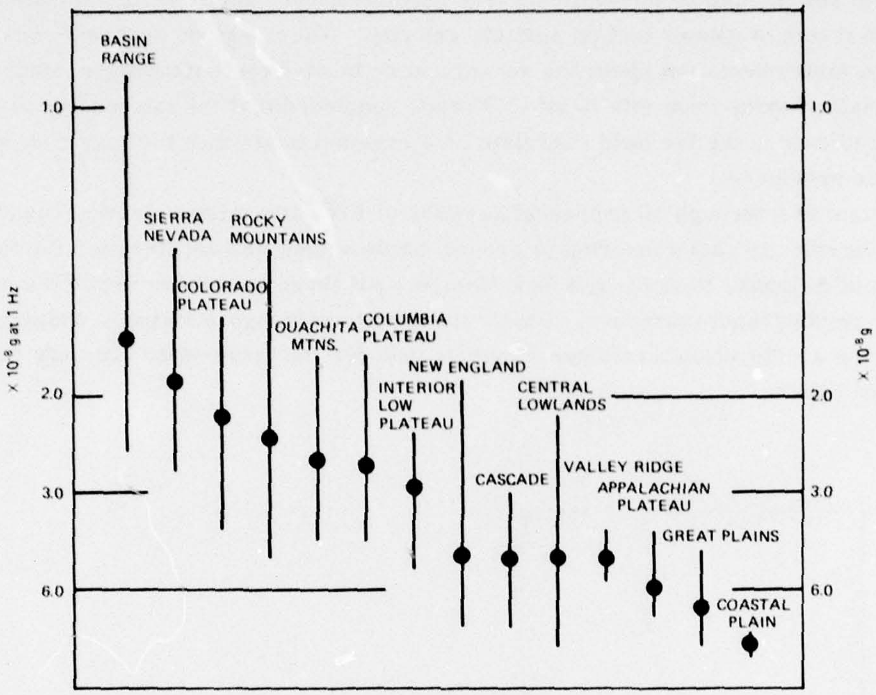

Figure 3. Ground Acceleration Mean and Range—Physiographic Provinces

2.3 Microseismic Investigations—American Southwest

The published literature reference to microseismic noise level investigations in the American Southwest is quite limited. The information available represents portions of studies having broader areas of concern. The following is based on extractions from these studies, and in some cases, the expansion and reformulation of the data in terms relevant to engineering interests. These investigations covered both the long (>5 sec) and short (<5 sec) period portions of the microseismic spectrum, and are only indicative of the microseismic noise levels for that sampled period. These levels are not to be extrapolated as representative in a secular sense. They should only be suggestive of the levels that can reasonably be anticipated.

2.3.1 FRANTTI's INVESTIGATION

In the early 1960's Frantti conducted an investigation of earth noise spectra for frequencies greater than 0.2 Hz.[13] He sampled microseismic noise levels in all the U.S. physiographic provinces and parts of Canada. He deployed wind protected

13. Frantti, G. (1962) The nature of high frequency earth noise spectra, Geophysics, XXVIII:547-562.

vertical seismometers in relatively free cultural areas, and in turn, formated the data in terms of ground motion particle velocity. There was no apparent consistency in instrumentation plant; the sensors were located on contrasting surface materials varying from site to site. Frantti concluded that the microseismic levels and gradients in the far field correlate on a regional basis with the major physiographic provinces.

Figures 4 through 10 represent portions of Frantti's microseismic ground particle velocity data converted to ground displacement and acceleration for the states of Arizona, Nevada, and New Mexico. All three states are within the same major physiographic province, namely the Basin and Range Province. Displacement and acceleration levels per Frantti's data for the three-state area are considered below.

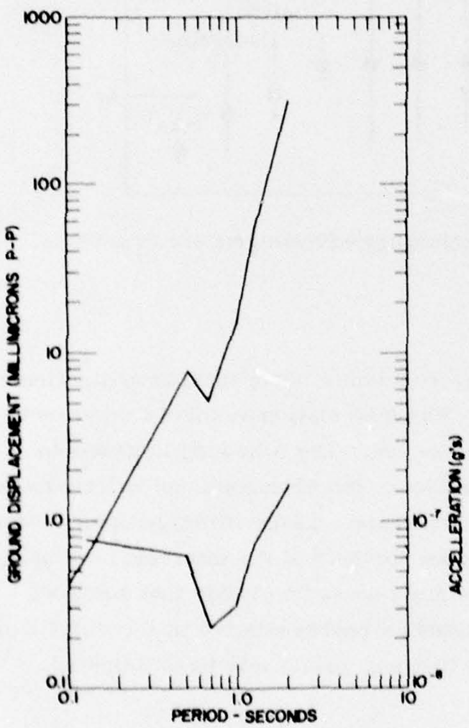

Figure 4. Displacement and Acceleration Spectra for Willow Springs, Arizona

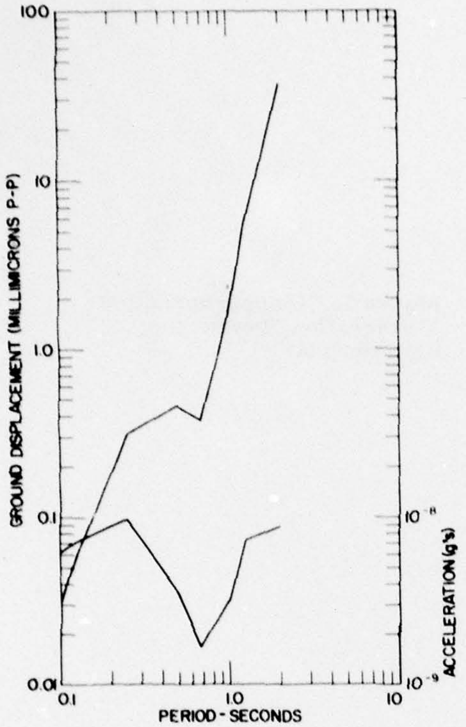

Figure 5. Displacement and Acceleration Spectra for Red Lake, Arizona

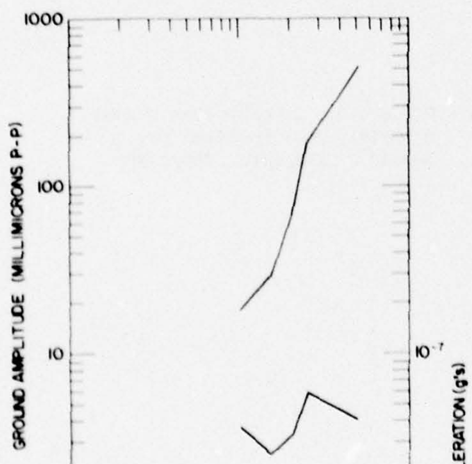

Figure 6. Displacement and Acceleration Spectra for Tucson, Arizona

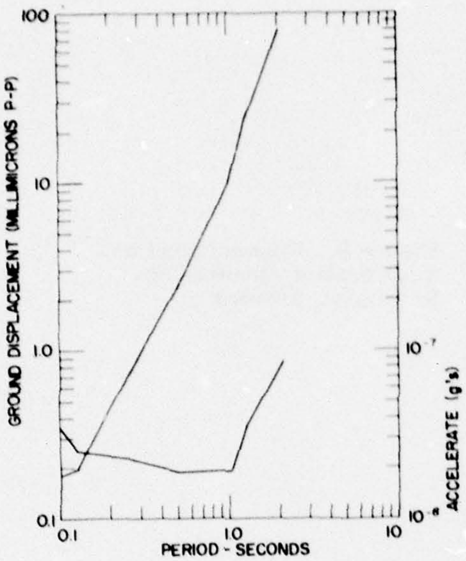

Figure 7. Displacement and Acceleration Spectra for Ely, Nevada

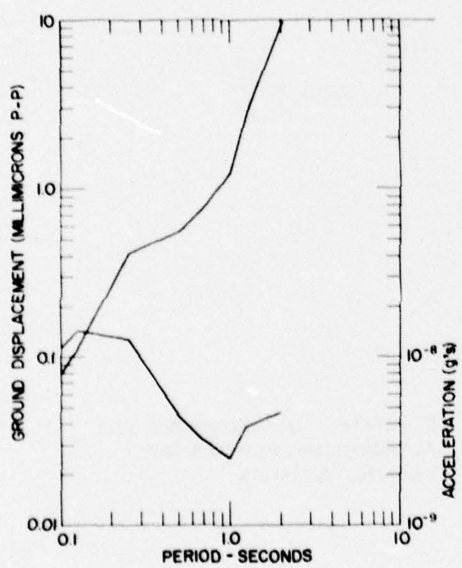

Figure 8. Displacement and Acceleration Spectra for Nevada Test Site, Nevada

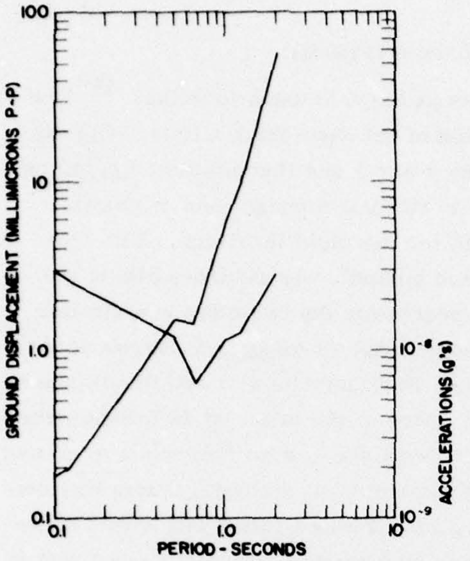

Figure 9. Displacement and Acceleration Spectra for Magdelena, New Mexico

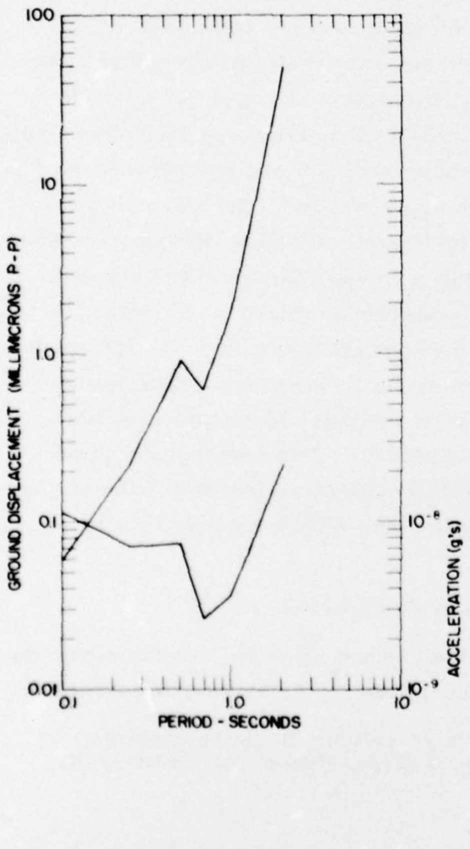

Figure 10. Displacement and Acceleration Spectra for Truth or Consequences, New Mexico

2.3.1.1 Arizona Microseismic Motion Levels (Frantti)

Frantti made microseismic measurements at eight Arizona locations.[13] The data sampling covered the north-central portion of the state from Climax Claims in the west to Tolan Lake in the East. Figures 4 and 5 are the calculated displacement and acceleration spectra for the maximum (Willow Springs) and minimum (Red Lake) sampled seismic background levels for the eight locations. The frequency band is from 0.5 to 10 Hz (0.1 - 2.0 sec period). As evidenced from the figures, both displacement and acceleration spectra for the two sites are similar in shape but Willow Springs is approximately one order of magnitude larger across the band in both displacement and acceleration. For instance at 1 sec the displacement and acceleration levels for Willow Springs are of the order of 15 millimicrons (p-p) and 3.0×10^{-5} mg's respectively, and at Red Lake 1.6 millimicrons (p-p) and 3.0×10^{-6} mg's respectively. The levels of the remaining six stations, that is Mormon Lake, Winslow, Tolan Lake, Kingman, Pica, and Climax Claims fall within these two extremes. There does not appear to be any appreciable differentiating trend in spectral amplitude between the eastern and western parts of the state. However, the displacement and acceleration spectra for all locations are similar in showing a distinctive branch point in the vicinity of the 1.5 Hz (0.67 sec) with the one exception of the Climax Claims' spectra where the branch point is opposite in polarity.

Figure 6 is a vertical component displacement and acceleration spectral plot calculated from ground velocity spectra over the frequency ranges 0.1 - 1.0 Hz (1-10 sec period). The measurements were made in the vicinity of Tucson by Shopland and Stevens.[14] Over the common frequencies with Frantti's observations, the Tucson displacement and acceleration spectra agree well with the calculated displacement and acceleration levels measured by Frantti at Willow Springs, the site of maximum seismic noise level. Willow Springs is approximately 325 km north north-west of Tucson. Although there are no apparent similarities in ground motion characteristics at the sampled locations on an east-west plane, it is of interest to note that Frantti's second noisiest location—Mormon Lake—closely approximates the Willow Springs motion levels, and that Willow Springs, Mormon Lake, and Tucson are separated by less than 30 min of longitude. This north-south trend cannot be explained by common geological characteristics as Mormon Lake is charterized by volcanics, Tucson by marine deposits, and Willow Springs by alluvial deposits.

2.3.1.2 Nevada Microseismic Motion Levels (Frantti)

Only two sets of seismic noise measurements were made by Frantti in Nevada, one at Ely and the second within the Nevada Test Site.[13] As before, the frequency

14. Shopland, R., and Stephens, E. (1962) Site selection—the noise problem, Problems in Seismic Background Noise, VESIAC Report No. 4410-32-X.

band of the spectral plots is 0.5 - 10 Hz (0.1 - 2.0 sec period). The calculated displacement and acceleration spectra are presented in Figures 7 and 8. The motional levels of the Ely data are significantly higher than that of the test site approaching an order of magnitude for periods larger than one second. As is comparatively evident, the Ely and the test site spectra respectively approximate the maximum and minimum extremes as deduced from Frantti's Arizona spectra.

2.3.1.3 New Mexico Microseismic Motion Levels (Frantti)

Frantti sampled microseismic motion levels at four locations in New Mexico, namely Truth or Consequences, Red Hill, Hope, and Magdalena.[13] Spectral motion levels for the maximum—Magdalena—and for the minimum—Truth or Consequences—for displacement and acceleration over the band 0.5 - 1.0 Hz are presented in Figures 9 and 10. As is evident, the Magdalena spectral motions are several factors larger than Truth or Consequences. However, the range of the extremes for New Mexico is not as large as for Arizona and Nevada. This could be attributed to geological variations (see Section 2.3.2) or cultural environment. Overall the microseismic motion levels in both displacement and acceleration are slightly more quiescent for the New Mexico locations than are those levels represented by the Arizona and Nevada spectra.

2.3.2 LONG RANGE SEISMIC MEASUREMENT PROGRAM

The Long Range Seismic Measurement Program (LRSM) was established under the government sponsored Project VELA-UNIFORM for the purpose in part of evaluating seismic noise levels at varied geological sites within the United States and Canada. Forty mobile seismic laboratories were used to cover the major physiographic provinces including the Basin and Range Province. Each mobile laboratory consisted of two sets of three-component seismographs; one set covering the short period spectrum with peak magnification near 2 Hz while the second set covered the long period spectrum having peak magnification at 0.04 Hz (25 sec-period).[15] Within the Basin and Range Province, LRSM mobile vans occupied sites in Arizona, Nevada, and New Mexico for periods up to 2 months. Measurements taken at these sites are presented as period-amplitude plots given in Figures 11 through 20. The average amplitude in millimicrons, corrected for instrument response, is plotted as a function of period. The measurements cover a period range of 0.3 to 1.4 sec for the short period systems and from 6 to 100 sec for the long period systems. Superimposed on each of the spectral plots is the average noise spectral curve of the earth's surface as adapted from Brune and Oliver.[16]

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15. Pena, C. (1967) Seismic Noise Survey, Volume 3, Geotech Technical Report No. 67-19.

16. Brune, J., and Oliver, J. (1959) The seismic noise of the earth's surface, Bull. Seism. Soc. Am. 49:349-353.

This curve is presented for comparison purposes with the microseismic noise level as sampled at each of the LRSM sites in the three states. Table 1 lists the stations contained in the spectral plots, by location, coordinates, and dominant geologic character. Computed acceleration levels for selected periods at each site are given under Figures 11 through 20. In addition, average maximum and minimum acceleration levels were calculated by Geotech based on peak ground amplitude observations from 38 continental sites.[12] Extractions from these calculations for the periods 1, 10, and 25 sec are presented in Table 2 for comparison with the calculated (equivalent) acceleration levels associated with Figures 11 through 20.

Table 1. Station Site Characteristics

Location	Coordinates	Rock Structure
Arizona		
1. Globe (GE-AZ)	33.78N - 110.53W	Shale
2. Heber (HR-AZ)	34.68N - 110.77W	Limestone
3. Jerome (JR-AZ)	34.83N - 111.98W	Limestone
4. Kohls Ranch (KH-AZ)	34.48N - 111.003W	Alluvium
5. Long Valley (LG-AZ)	34.40N - 111.55W	Volcanic Tuff
6. Nazleni (NL-AZ)	35.90N - 109.57W	Shale
7. Nazleni 2 (NL2-AZ)	35.80N - 109.65W	Siltstone
8. Snowflake (SF-AZ)	34.43N - 109.02W	Limestone
9. Seligman (SG-AZ)	35.63N - 113.27W	Limestone
10. Sunflower (SN-AZ)	33.87N - 111.70W	Granite
11. Springville (SV-AZ)	34.18N - 109.02W	Sandstone
12. Williams (WM-AZ)	35.42N - 112.22W	Limestone
13. Winslow (WO-AZ)	34.88N - 110.62W	Sandstone
New Mexico		
Location	Coordinates	Rock Structure
1. Las Cruces (LC-NM)	36.58N - 106.60W	Limestone
2. Gnome (GN-NM)	32.27N - 103.85W	Caliche
Nevada		
Location	Coordinates	Rock Structure
1. Austin (AT-NV)	39.48N - 117.007W	Granodiorite
2. Caliente (CQ-NV)	37.62N - 114.41W	Limestone
3. Eureka (EK-NV)	39.22N - 115.72W	Shale
4. Mina (MN-NV)	38.43N - 118.02W	Complex Metamorphic (Sedimentary)
5. Winnemucca (WI-NV)	41.35N - 117.47W	Limestone/Metamorphics
6. Warm Springs (WZ-NV)	38.19N - 116.30W	Granodiorite

Table 2. Averaged Maximum/Minimum Acceleration Levels—North America

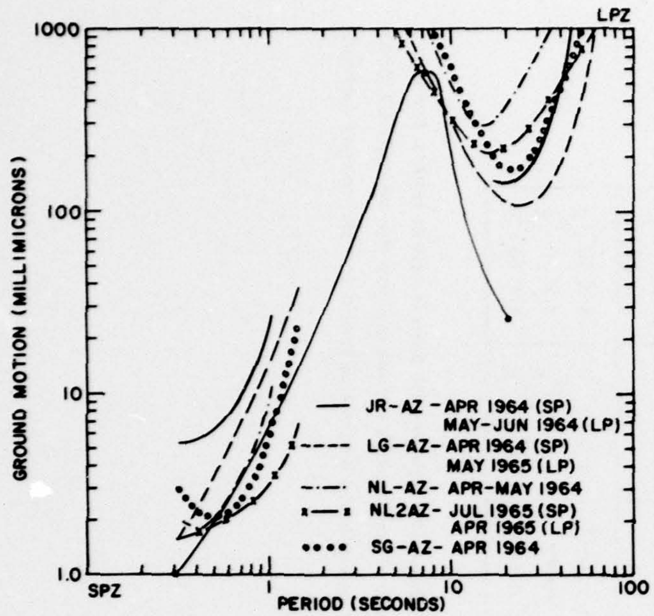
	Period (sec)		
	1	10	25
Average Maximum Acceleration	1×10^{-7}g	2×10^{-8}g	3×10^{-9}g
Average Minimum	3×10^{-9}g	7×10^{-9}g	8×10^{-10}g

The averaged maximum and minimum of the peak acceleration from the overall LRSM short period data, based on the LRSM continental stations, are 3×10^{-7}g and 3×10^{-9}g respectively, and 2×10^{-8} and 6×10^{-10}g, respectively for the long period 10 - 60 sec) LRSM data.[12] As can be argued from Figures 11 through 20, the American Southwest is one of the more quiescent areas in terms of microseismic noise within the continental limits. From the measured Arizona, Nevada, and New Mexico data, equivalent acceleration levels averaged for periods 1, 10, and 25 sec are given in Table 3.

Table 3. Three-State Averaged Acceleration Levels

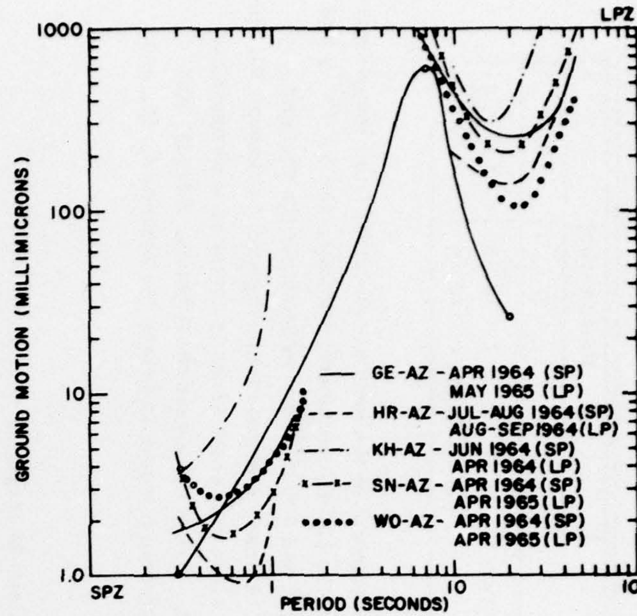
	Period (sec)		
	5	10	25
Arizona	3×10^{-8}	9×10^{-9}g	1×10^{-9}g
New Mexico	——	1×10^{-8}g	2×10^{-9}g
Nevada	3×10^{-8}	1×10^{-8}g	1×10^{-9}g

Comparatively, the averaged sampled equivalent acceleration levels for the three-state region approaches the averaged peak minimum for the sampled LRSM continental data within the short period band while the trend for the longer periods is nearer the averaged maximum.



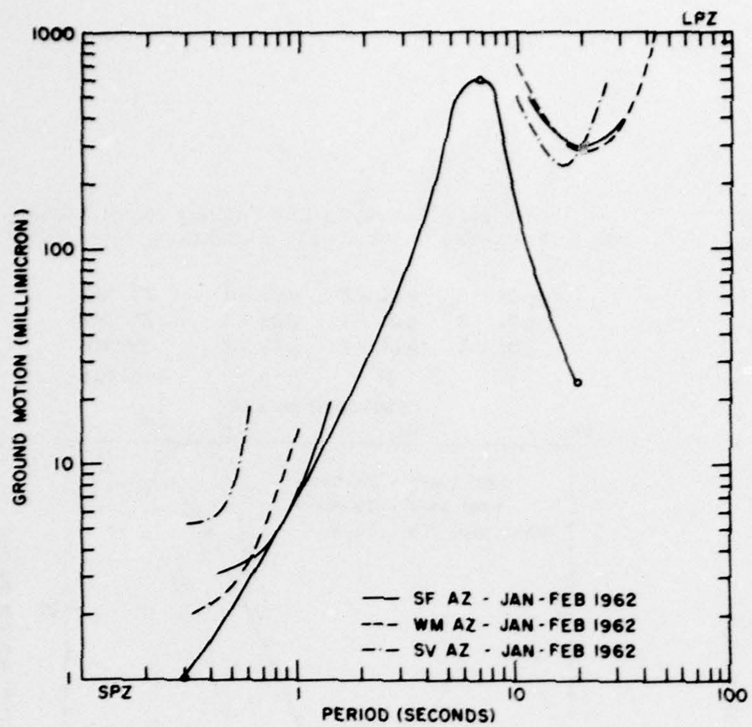
STATION	1	10	25
JR–AZ	6×10^{-8}	6×10^{-9}	6×10^{-10}
LG–AZ	4×10^{-8}	6×10^{-9}	4×10^{-10}
NL–AZ	2×10^{-8}	9×10^{-9}	2×10^{-9}
NL2–AZ	7×10^{-9}	6×10^{-9}	9×10^{-10}
SG–AZ	2×10^{-8}	1×10^{-8}	4×10^{-10}

Figure 11. Computed Acceleration Levels (g's) for Jerome, Long Valley, Nazleni, Nazleni 2, and Seligman, Arizona



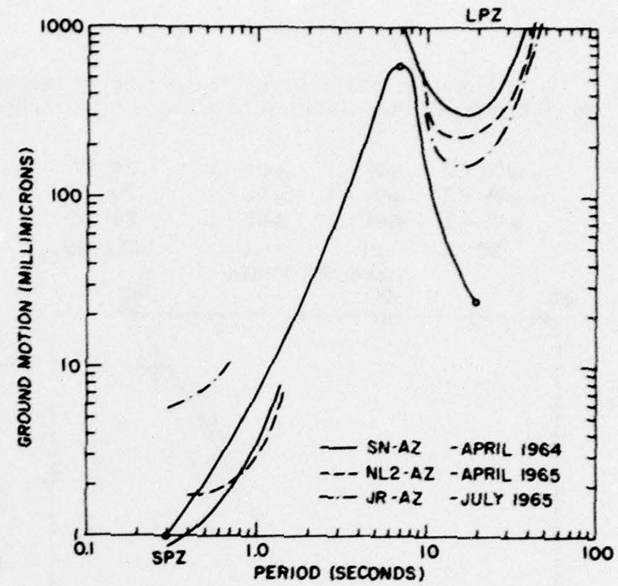
STATION	1	10	25
GE–AZ	9×10^{-8}	8×10^{-9}	8×10^{-10}
HR–AZ	5×10^{-9}	4×10^{-9}	5×10^{-10}
KH–AZ	1×10^{-7}	1×10^{-8}	2×10^{-9}
SN–AZ	6×10^{-9}	1×10^{-8}	9×10^{-10}
WO–AZ	1×10^{-8}	7×10^{-9}	4×10^{-10}

Figure 12. Computed Acceleration Levels (g's) for Globe, Heber, Kohls Ranch, Sunflower, and Winslow, Arizona



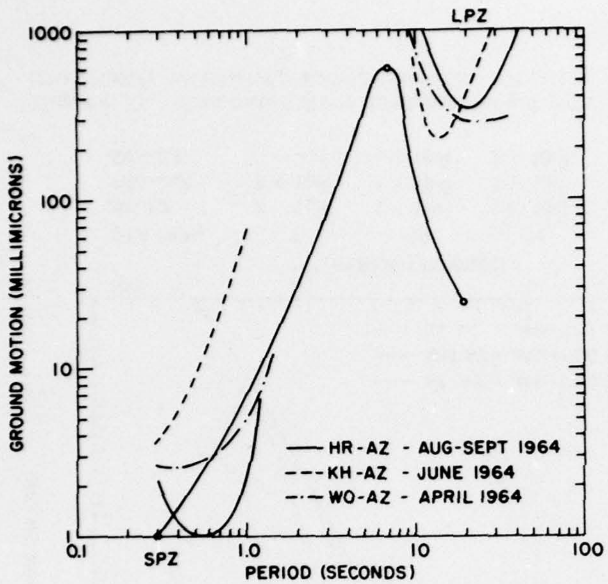
STATION	1	10	25
SF-AZ	2 × 10-8	1 × 10-8	1 × 10-9
WM–AZ	3 × 10-8	1 × 10-8	1 × 10-9
SV–AZ	——	1 × 10-8	2 × 10-9

Figure 13. *Computed Acceleration Levels (g's) for* Snowflake, Williams, and Springville, Arizona



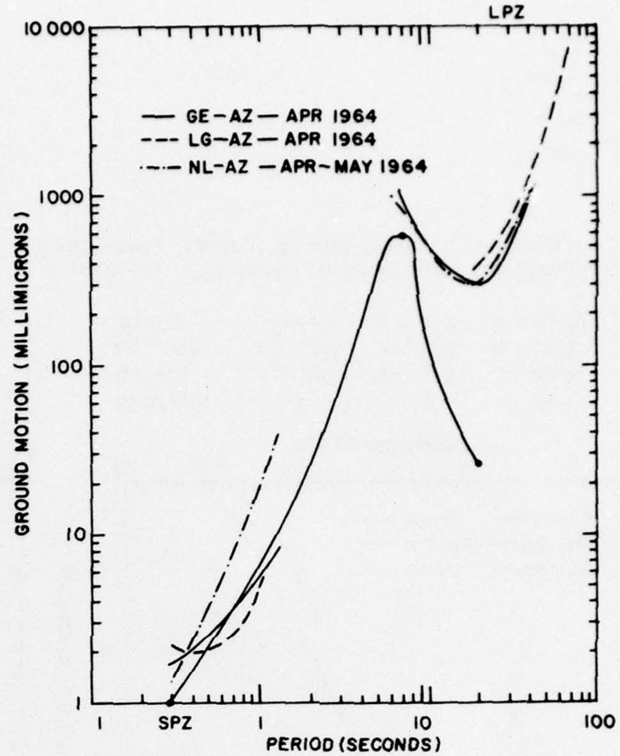
STATION	1	10	25
SN–AZ	7 × 10-9	1 × 10-8	1 × 10-9
NL2–AZ	6 × 10-9	7 × 10-9	6 × 10-9
JR–AZ	——	6 × 10-9	8 × 10-10

Figure 14. Computed Acceleration Levels (g's) for Sunflower, Nazleni 2, and Jerome, Arizona



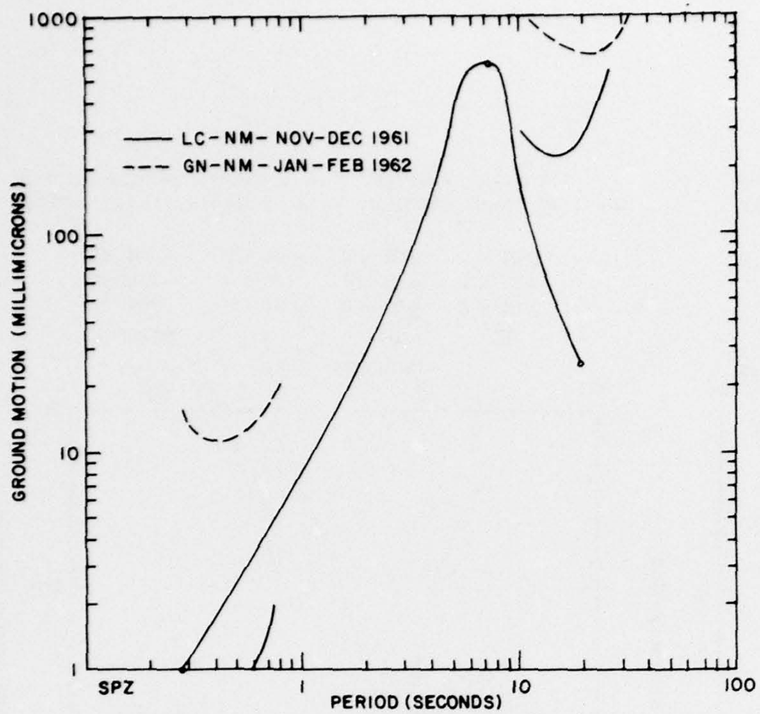
STATION	1	10	25
HR–AZ	2×10^{-9}	2×10^{-8}	1×10^{-9}
KH–AZ	1×10^{-7}	1×10^{-9}	3×10^{-9}
WO–AZ	1×10^{-8}	2×10^{-8}	9×10^{-10}

Figure 15. Computed Acceleration Levels (g's) for Heber, Kohls Ranch, and Winslow, Arizona



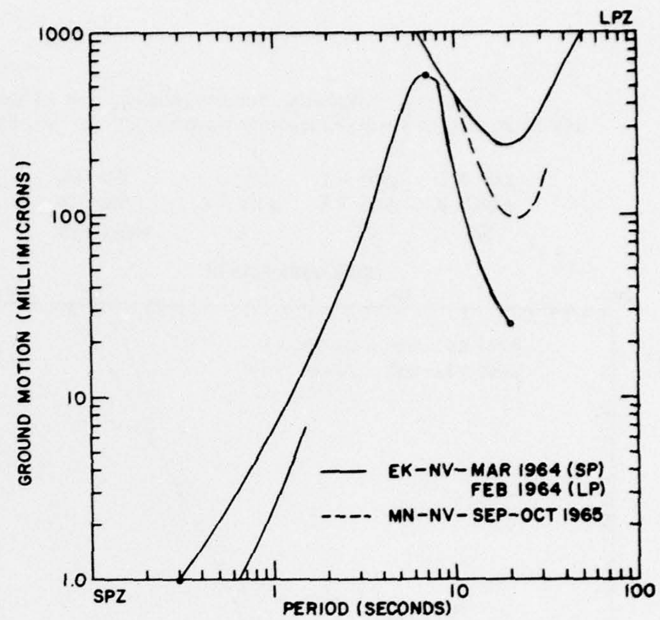
STATION	1	10	25
GE–AZ	1×10^{-8}	1×10^{-8}	1×10^{-9}
LG–AZ	1×10^{-8}	1×10^{-8}	2×10^{-9}
NL–AZ	4×10^{-8}	1×10^{-8}	2×10^{-9}

Figure 16. Computed Acceleration Levels (g's) for Globe, Long Valley, and Nazleni, Arizona



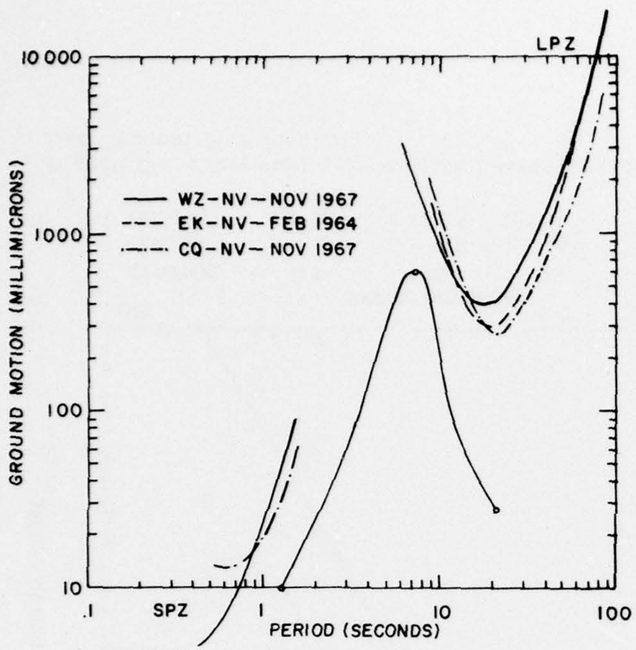
STATION	0.7	10	25
LC–NM	6×10^{-9}	6×10^{-9}	2×10^{-9}
GN–NM	7×10^{-8}	2×10^{-8}	2×10^{-9}

Figure 17. Computed Acceleration Levels (g's) for Las Cruces, New Mexico



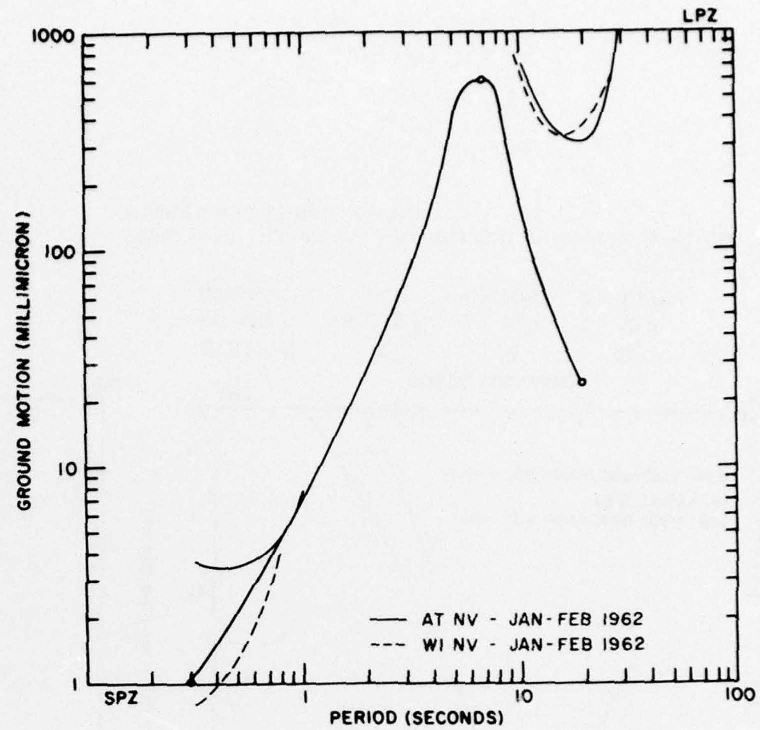
STATION	1	10	25
EK–NV	5×10^{-9}	1×10^{-8}	1×10^{-9}
MN–NV	—	1×10^{-8}	9×10^{-10}

Figure 18. Computed Acceleration Levels (g's) for Eureka and Mina, Nevada



STATION	1	10	25
WZ–NV	6×10^{-8}	2×10^{-8}	2×10^{-9}
EK–NM	——	2×10^{-8}	1×10^{-9}
CQ–NV	4×10^{-8}	2×10^{-8}	1×10^{-9}

Figure 19. Computed Acceleration Levels (g's) for Warm Springs, Eureka, and Caliente, Nevada



STATION	1	10	25
AT–NV	2×10^{-8}	1×10^{-8}	2×10^{-9}
WI–NV	——	1×10^{-8}	2×10^{-9}

Figure 20. Computed Acceleration Levels (g's) for Austin and Winnemucca, Nevada

2.3.2.1 Discussion

Microseismic levels are colored by the local station geology. The Arizona spectra (Figures 11 through 16) predicated on station geological foundations, conform to expected levels. That is, for the station located on alluvial deposits (KH-AZ), a higher order noise level is evident compared to a station located on a granite base such as (SN-AZ). The spectra for those stations fixed on sedimentary rock and volcanic extrusives generally fall between as expected. Compared with noise spectral plots of Brune and Oliver, the Arizona short-period spectra are compatible, while the long-period spectra are consistently of a higher order of intensity and shifted in frequency to the longer periods for equivalent world average levels.

The New Mexico spectra, Figure 17, consists of only two station samples which, in turn, are quite limited in themselves. However, the short period microseismic noise levels for both stations are cut-off conspicuously at 0.33 sec (3 Hz). In comparison the majority of the Arizona and Nevada station spectra terminate above 1 second. The longer period New Mexico spectra are substantially of the same order of intensity and corresponding period as the Arizona spectra.

Nevada spectra, Figures 18 through 20, are similar to—as was the case in Frantti's data—the Arizona spectra at both the short and longer periods manifesting comparable intensity levels. Data spectral points consistently cluster around the Brune-Oliver curve for the shorter periods and are in good station agreement at the longer period.

With the exception of the observed short period cut-off below 1 sec for the two New Mexico stations, which due to the limited sample is in itself highly inconclusive as being indigenous, the LRSM microseismic spectral levels for the sampled three-state area are in good agreement, exhibiting conspicuously low short-period levels compared to published world averages.

2.3.3 TONTO FOREST SEISMOLOGICAL OBSERVATORY DATA

Stationary, coherent background noise field determinations were made in 1968 and 1969 by Texas Instruments, Inc. at the Tonto Forest Seismological Observatory, Payson, Arizona. Data were collected via an extended seismic network. The published data are in terms of frequency-wavenumber (f-k space). Of note in this investigation is the characterization of summer and winter noise fields.[17] Higher surface mode energy from the northeast is observed during both winter and summer periods at periods above 4 seconds. The most significant difference in the spatial organization of the summer and winter noise fields is the winter increase in energy from the northwest characterized by discrete periods of 8 seconds. In other words,

17. Rekieta, T. (1970) Noise Study for TFO Extended Short-Period Array, Texas Instrument Report No. 5.

as expected, the contribution of the storm microseismic branch of the microseismic spectrum predominates. This is attributed to Pacific cyclonic activity. A slight increase is also observed in surface mode energy from the southwest in the "winter" data, again attributable to Pacific cyclonic activity but not to the degree as occurring in the more storm orientated northwest Pacific areas.

3. CONCLUSIONS

From the limited published and calculated data covering the Basin and Range Province, microseismic intensity levels for the shorter periods are generally of an order of magnitude smaller compared with continental and world-wide averages. Comparatively, the longer periods (> 10 sec) are slightly greater in intensity characterized by a shift in period. Intensity levels within New Mexico exhibit a greater degree of quiescence compared with Arizona and Nevada, which, in turn, are most comparable. Stationary background noise fields are dominant in the winter periods having source orientation primarily in the northwest and secondarily in the southwest.

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