RESEARCH IN SEISMOLOGY

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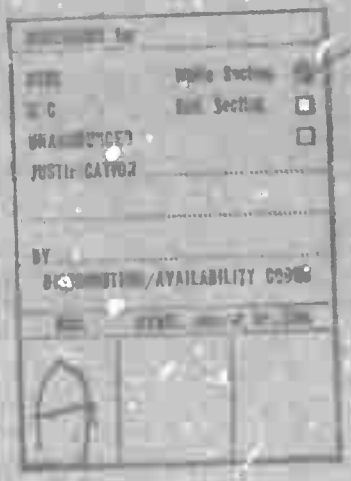

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13. ABSTRACT

This report concerns research related to the discrimination between small-magnitude earthquakes and explosions. The principal findings are:

The source spectra of small-magnitude earthquakes in the New Madrid (Lower Mississippi Valley) seismic region can be divided into two classes, one of which is deficient in low-frequency energy.

In most cases the source spectrum of P waves from deep-focus South American earthquakes is flat at the low frequencies and falls off as the inverse square of the frequency at the high frequencies.

The absorption of surface waves is much smaller east of the Rocky Mountains than west of them. This fact must be taken into account when computing surface-wave magnitudes of small events.

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Introduction

During the six months covered by this report attention has been centered on problems related to discrimination of small-magnitude events. This includes studies on the shape of the source spectrum for shallow and deep events, on the attenuation of short-period surface waves, and of magnitude formulas for m_b and M_s that can be used for small events.

Eight earthquakes with m_b values between 2 and 4 were detected, and their hypocentral coordinates determined, during the interval 1 January to 30 June, 1972. All these earthquakes were located in the New Madrid Seismic Zone. They provide additional data for our studies of the spectral properties and magnitude relations of small, shallow-depth events.

Spectral Analysis Studies of Events in the New Madrid Seismic Zone.

A study of the spectral content of 17 earthquakes established that the earthquakes divide into two classes, one of which is deficient in low-frequency (long period) energy. The spectra were determined by both digital and analog methods, to rule out the possibility of errors in the calculation of the spectra. The two classes of earthquakes also differ in their macroseismic effects. The events deficient in the long-period motion are characterized by relatively higher intensity at the epicenter, but a smaller area of perceptibility.

The spectral differences are seen for both the P and S (or Lg) waves. As the cause of the differences is not yet certain, study is continuing to determine the explanation. The spectral differences appear not to be related to depth of focus or location within the seismic zone, but rather to something different in the faulting process.

The existence of small, shallow-depth earthquakes with spectra rich in high frequencies (or relatively poor in low frequencies) is important to the VELA-Uniform problem in terms of application of discrimination criteria.

Spectral Analysis Studies of Deep-Focus South American Earthquakes.

Studies to determine the source spectrum of deep-focus South American earthquakes from seismograms obtained at South American stations were begun in the summer of 1971. During the six-month period covered by this report the data of more earthquakes were analyzed.

From the additional analyses we now can conclude that in most cases the source spectrum for the P waves falls off as f^{-2} for the high frequencies and is flat at the low frequencies. There is one exception to this statement; the spectrum of the 5 March 1965 earthquake calculated from the ANT seismograms is peaked at intermediate frequencies. The shape of these spectra is in general consistent with that predicted by the theories of Brune and of Berckhemer and Jacob. Although both theories give seismic moments of the same order of magnitude, Brune's theory gives consistently longer fault lengths and lower stress drops.

Attenuation and Magnitude Relations.

Studies of the attenuation of seismic surface waves have established that the empirical M_L scale of Richter and M_S scale of Gutenberg and Richter can be given a theoretical foundation. These studies further established that magnitude formulas of the type

$$M = B + C \log \Delta + \log A/T,$$

which are in common use, only are valid over a limited range of epicentral distances. Application of such formulas to data outside the range of validity will lead to incorrect magnitude determinations.

The attenuation studies also established that the absorption of short-period surface waves is much smaller east of the Rocky Mountains than west of them. Thus magnitude formulas which use data at regional distances (about 200 to 2000 km) that are obtained empirically from California and NTS events are not valid for Central United States earthquakes. In general they result in overestimation of the surface-wave magnitude.

Of interest to VELA-Uniform objectives is the likelihood that geologic structure, and thus surface-wave attenuation, of central Asia is likely more similar to that in the Central United States than to California and Nevada.

Reports and Scientific Papers Produced during the Report Period.

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6. Rodriguez, R. and C. Kisslinger, "Spectral Classification of New Madrid Earthquakes," presented to 1972 Spring Meeting of the American Geophysical Union.

7. Nuttli, O. W. "Seismic Wave Attenuation and Magnitude Relations for Eastern North America," presented to 1972 Spring Meeting of the American Geophysical Union. (A manuscript of the same title has been submitted to the Journal of Geophysical Research.)