Microseism Activity in Indiana

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Abstract

The microseism activity recorded at the Indiana University Seismological Laboratory was analyzed for the period from January 1969 to December 1970. In addition to occasions of sharp, sporadic activity associated with cyclones over the Atlantic Ocean, a general background level of microseisms was detected. The intensity of the background level during the northern hemisphere winter was about four times the activity at the summer solstice.

In a separate but related study the track of the October 1971 hurricane Ginger was compared with microseism activity in Bloomington. As the hurricane left the open ocean for the continental shelf of the Carolinas, microseism activity increased. A sharp decline in microseism level correlated with the landfall of the hurricane's eye.

Introduction

This is a progress report on the study of midwestern microseism activity being conducted at Indiana University. By microseisms we mean small bundles of sinusoidal oscillations or pendulum vibrations which are quite distinct from an earthquake or a blast record on a seismogram (1, 4). Their period generally ranges from 4 to 10 sec. They show the phenomenon of beats. A microseism storm may last for a few days and is closely related to the weather. Four theories have been proposed for their generation (2):

1) Theories of local origin, meteorological or geological at or near the recording station.

2) Theories of thermal or barometric gradients travelling over continental areas.

3) Theories connected with storms or storm waves at sea. Also called standing sea wave pattern theories.

4) Theories of surf-pounding or breaking on the rocky coast of a continent.

Our investigations have shown that storms over the sea, especially when they are centered on the continental shelf, play a dominant role in generating microseisms.

Observation Techniques

Our seismological observatory at Bloomington is equipped with three component (*i.e.*, vertical, north-south, and east-west) short-period (about 1.0 sec) Benioff seismographs and three component long-period (about 15.0 sec) Sprengnether seismographs. Minute and hour time-marks are controlled by a local crystal clock. The time-marks are calibrated daily against radio-broadcast, standard time.

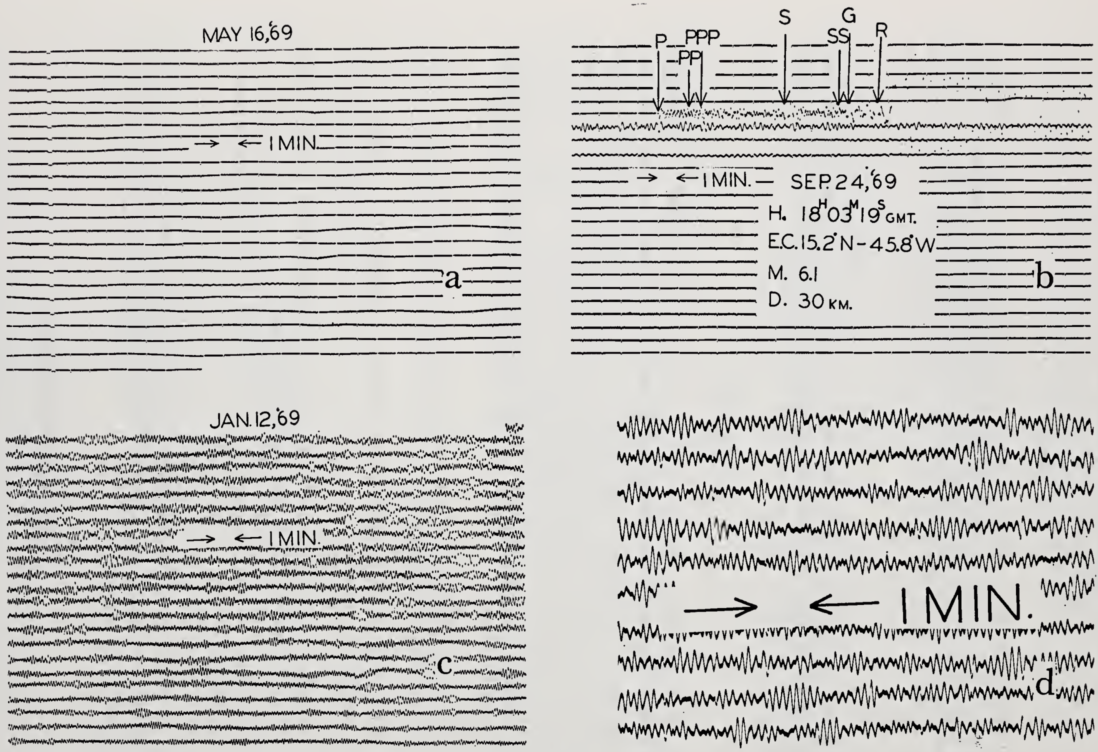

FIGURE 1. *Seismograms (long period vertical). Time begins at the top and reads left to right.* A) *A quiet day;* B) *A typical moderate earthquake. Labeled arrows point to various phases described in the text;* C) *A microseism storm. Note the difference from figures 1A and 1B;* D) *Figure 1C magnified about 3 times. Note the sinusoidal form and beating envelope.*

The Character of Microseisms

On a quiet day we have neither a microseism storm nor an earthquake recorded. The appearance of a seismogram on such a day is shown in Figure 1a. The trace amplitudes are small. An earthquake creates a seismogram record having a unique character. Figure 1b shows such a seismogram of a moderately strong earthquake which occurred at the Atlantic Ridge. It had an origin time of 18 hours 3 min 19 sec GMT. The epicenter was at 15.2° north and 45.8° west. Its magnitude was 6.1 and the depth of focus was about 30 km. All these facts may be determined by analyzing the seismogram in terms of body wave phases P and S and their reflections from the surface of the Earth, PP and PPP. In addition, the surface wave phases, Love (G) and Rayleigh (R) waves, may be analyzed for further confirmation. These phases are marked on the Seismogram in Figure 1b.

The seismogram of a microseism storm is markedly different from that of an earthquake as shown in Figure 1c. Figure 1d shows a magnified portion of the record shown in Figure 1c. The character of the seismogram is less variable with time, and duration of recorded activity is much greater. Microseisms consist of surface waves, Rayleigh and Love waves, with Rayleigh wave amplitudes dominating. A storm generally lasts for a day or two and then diminishes to normal background level.

Seismograms of a microseism storm give the impression of sinusoidal oscillations modulated by beats as shown in Figure 1d. Oscillation periods range from 4 to 10 sec and vary with trace amplitude. In general the periods of microseisims have been observed to increase with an increase in amplitude.

Annual Variation in Microseism Level

We analyzed the microseism data at Bloomington for two consecutive years, 1969 and 1970. Maximum trace amplitudes (half of the peak to peak value) on vertical component, long-period seismograms were measured for consecutive six-hour intervals and plotted against time. Data for the years 1969 and 1970 are shown in Figure 2. The similarity between the activities of the two years is striking. It was noted that:

1) Microseism activity was at its minimum level from about the first of May to the end of August.

2) After August, the average general activity began to increase and was about 2 to 3 times that of the activity in the summer months.

3) From November to April, the average general activity was at its maximum level—about 4 to 5 times that of the summer months. In addition to a general rise in level, the frequency of storms increased during the winter. These storms had amplitudes of 10 to 30 times those of the average activity during the summer months.

4) The microseism storms developed slowly with amplitude gradually tapering off. There were no sudden increases or decreases of a microseism storm; rather, the activity appears to develop smoothly in time.

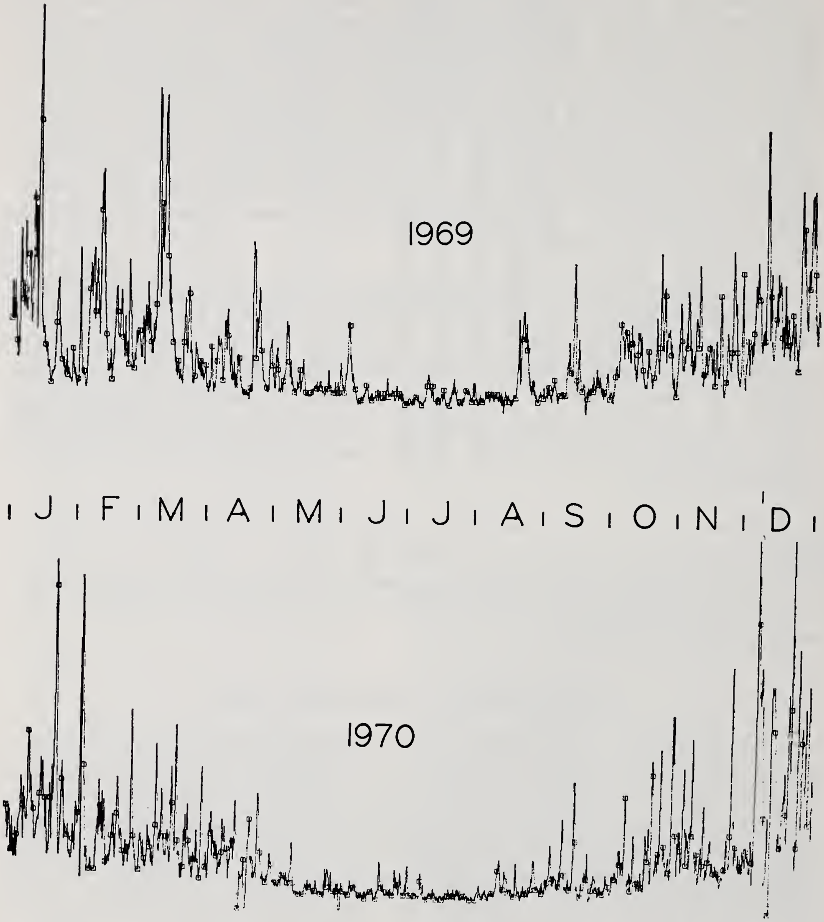

FIGURE 2. *Graph showing annual variation of microseism activity for the year 1969 and 1970. Maximum trace amplitude (half the peak to peak value) is plotted on the vertical axis. Sharp peaks are short-lived storms.*

We postulate that the high general activity in winter months, with its microseism storms occurring in this period, correlates with meteorological phenomena. We further believe that storms occurring at lower latitudes in winter months provide coupling of energy to the crust through water along the continental shelf. In summer months storms are concentrated at higher latitudes and less energy is transmitted to the continents (3).

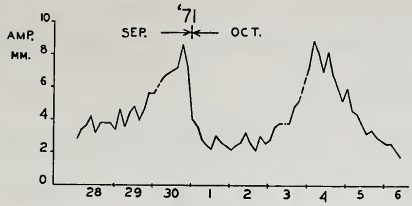

FIGURE 3. *Plot of microseism activity during the fall of 1971. Movement of the Hurricane Ginger across the continental shelf caused the two peaks.*

Microseisms and Hurricane Ginger, 1971

In a separate but related study we analyzed a particular storm, Ginger, which occurred on the eastern coast of the United States during the period of September 28 to October 6, 1971. Microseism activity during this period, in terms of trace amplitude *vs.* time, is plotted in Figure 3. In that figure there are two periods of high activity and in between, the activity was low. These fluctuations correlate very well with the location of the storm center with respect to the continental shelf. Surface weather maps for the period September 30 to October 6, 1971, are presented in Figure 4.

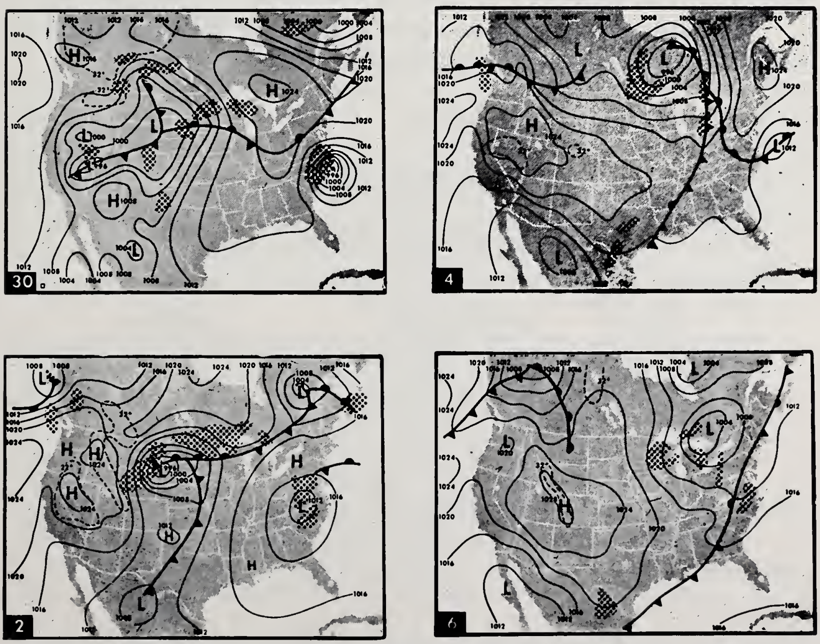

FIGURE 4. *Surface weather maps for the period Sept. 30 to Oct. 6, 1971, showing the progress of Hurricane Ginger.*

It was observed that:

1) On September 30, when the hurricane was centered on the continental shelf (Fig. 4), the microseism activity was at its maximum level (Fig. 3).
2) On October 2, when the hurricane had moved from the continental shelf and was centered on the continent (Fig. 4), the microseism activity decreased to its minimum level (Fig. 3).
3) On October 4, when the hurricane was again centered near the continental shelf, the microseism activity increased considerably.
4) On October 6, when the hurricane moved farther away from the continental shelf toward the sea, the microseism activity returned to normal background level.

Conclusions

From these two studies we deduce:

1) That microseism storms in the midwest are caused by meterological storms over the eastern continental shelf.
2) That the general high level of microseisms during the northern hemisphere winter months reflects a general high level of cyclonic activity for the period.

Acknowledgment

We wish to thank Professor Judson Mead for his interest and encouragement during the course of this study.

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