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Abstract

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THE USE OF LONG-PERIOD MICROSEISMS FOR OBTAINING INFORMATION ABOUT STORMS IN THE OCEAN

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GEOPHYSICS

Numerous attempts at the timely detection of storms in the open parts of the oceans from microseism records at seismic stations have not led to the desired result. Microseismic information about such storms either is not detected at all, or arrives with a large delay relative to the time of storm development ([1,2,4,5]).

To obtain information about such storms, microseisms with periods of less than 10 sec have hitherto been used, since they have the greatest energy level. Accordingly, the seismic-recording apparatus was adjusted for maximum sensitivity to oscillations with periods in the indicated range. When propagating in the Earth' s crust, oceanic-type microseisms with such periods are attenuated many times more strongly than when propagating in continental-type crust ([3,6]). Therefore, when storms are located in the open ocean, the microseisms formed in the region of storm action reach continental observation points so weakened that the level of the permanently existing microseismic background, whose sources are confined to coastal zones, proves to be considerably higher than the level of storm microseisms. In this connection, no noticeable change in the amplitudes and periods of microseisms is observed in the records of seismic stations.

However, after some time has elapsed following the beginning of storm activity in the open ocean, depending on the distance of the storm from the coasts, characteristic microseisms are in many cases detected in the records of seismic stations; their periods are noticeably greater than the periods of oscillations in the microseismic background. The cause of microseisms of this kind, observed on the territory of Europe, is swell from cyclones over the North Atlantic. The formation of microseisms by swell occurs mainly off the Norwegian coasts of the Scandinavian Peninsula ([1,2]).

In these cases, the microseismic information about storms in the North Atlantic is delayed by the time required for the swell to propagate from the storm region to the coasts of Scandinavia, which is often several days. But even this information is absent if the cyclones are at sufficiently great distances from Scandinavia, for example south of the 50th parallel.

At the beginning of 1962 we undertook an attempt to obtain more complete and more timely information about storms in the North Atlantic, based on the recording of long-period microseisms.

The assumption that oscillations with periods greater than 10 sec are present in the microseism spectrum was based rather on theoretical ideas about the propagation of elastic surface waves in the Earth' s crust than on experimental data ([6,7]). From experimental data, only isolated cases of recording long-period microseisms were known ([8,9]).

The transition to the region of long-period microseisms for solving the stated problem was prompted by the following considerations:

1. Long-period microseisms propagate in the Earth' s crust with less attenuation than microseisms with periods of less than 10 sec.
2. For isolating weak long-period microseisms against the background of the shorter-period oscillations that constitute the visible microseismic background, frequency selection can be successfully applied.
3. The periods of microseisms are in direct dependence on the periods of sea waves. Therefore long-period microseisms formed by swell near the coasts should be observed earlier than short-period microseisms, since the propagation velocity of swell is proportional to its period.

From theoretical and experimental dispersion curves for surface elastic waves propagating in the Earth' s crust, it follows that the minimum group velocity (maximum energy) of the first harmonic corresponds to oscillations with a period of about 18 sec. ([6]; [7]). On this basis, we organized frequency-selective recording of microseisms with periods of about 18 sec. The frequency-selective station was located near Moscow. It consisted of a group of several SVK seismographs tuned to a natural-oscillation period of 18 sec. The recording galvanometer had the same period of free oscillations. Between the seismographs and the galvanometer there were filters that attenuated oscillations with periods different from 18 sec. A group of seismographs was used because the amplitudes of 18-second microseisms, according to the available data, are measured in millimicrons, i.e., are extremely small.

Reliable recordings of microseisms were obtained during the period from the end of October 1962 to April 1, 1963. Observations were carried out 2–3 times per day for 30 min each time.

A graph of the variation in microseism amplitudes, constructed from observations over 4 months, was compared with a graph of the variation in the intensity of cyclonic activity over the North Atlantic. The calculation included cyclones located approximately between 35 and 65° N latitude and at distances of more than 500 km from the European coast, all the way to the shores of America.

Cyclones acting over the Norwegian and Greenland Seas, as well as west of England and France at distances of less than 500 km from the coasts, proved to be less active generators of 18-second microseisms than cyclones over the North

Atlantic far from the shores of Europe. They were therefore not included in the calculation.

A joint analysis of the microseismic data and the meteorological conditions over the above-mentioned region of the North Atlantic showed that an increase in cyclone intensity was invariably accompanied by an increase in microseism amplitudes. The lag of the microseisms relative to the time of cyclone development in most cases was about 18 hours. The maximum lag did not exceed 30 hours. During the observations, cyclones with the indicated lag were found that were located south of Greenland at a distance of about 3000 km from the shores of Europe.

Of the 30 cyclones that occurred in the specified region during the observation period, 28 were accompanied by "storms" of 18-second microseisms. It should be noted that, according to observations from ordinary seismic stations, in the best case it is possible over the course of a year to detect storms in the open parts of the oceans in no more than 1–2 cases. This conclusion was reached, for example, by Carder and Eppley ([5]).

The general conclusion is that frequency-selective recording of microseisms with periods of about 18 sec. provides information on storms in the North Atlantic in which hydrometeorological and maritime institutions may be interested. Further studies should be directed toward a more detailed investigation of the conditions of formation of long-period microseisms.

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Note: Figure translations are in progress. See original paper for figures.