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**Abstract**

**Full Text**

**GEOPHYSICS**

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## **ON SOME CASES OF THE EXCITATION OF MICROSEISMS IN THE ATLANTIC AND PA- CIFIC OCEANS**

*(Presented by Academician D. I. Shcherbakov on 30 XI 1959)*

Great interest in the study of microseisms has been caused by the possibility of correlating them with meteorological conditions. Numerous observations of microseisms can be used to identify cyclonic and storm processes. It has been theoretically established <sup>(1)</sup> and practically confirmed that the origin of microseisms is due to sea disturbance of the surf-beat type (standing waves), arising, in turn, when winds and waves converge or when they are reflected from steep rocky shores. Determining the coordinates of the source of microseism excitation and tracing its trajectory makes it possible to locate the cyclonic region, which is important for hydrometeorological forecasts and maritime transport. The study of the commonality of the paths of propagation of microseisms can provide additional material for studying the waveguides of the Earth's crust. However, in works <sup>(2-4)</sup> the inaccuracy of locating the foci of microseism generation is noted. In work <sup>(5)</sup> we developed a method that gave good agreement with the meteorological situation and wave conditions in the Caspian Sea. In the present work this method is applied to other regions using observations from seismic stations under the IGY program.

A complex meteorological situation over the ocean can give rise to many sources of microseism excitation. A synchronous change in microseism frequency over time at different seismic receivers serves as confirmation of a common source of excitation, just as at transmitting and receiving radio stations one and the same combination of signals is reproduced. Therefore, from the multitude of seismic stations located on the coast and on the continent, it is necessary to combine those groups that give an identical sweep of microseism periods in time. After synchronism of frequencies has been established, it may be considered that the group of seismic stations that record these frequencies in the same way has one and the same source of microseism excitation. The source of microseism excitation was found as the geometric locus of points on the surface of a sphere satisfying the condition

$$\frac{A_1^{n_1}}{A_2^{n_2}} = \frac{d_2}{d_1} = k,$$

Figure 1

Figure 1: Figure 1

Figure 2

Figure 2: Figure 2

where  $A_1, A_2$  are the amplitudes of the microseisms;  $d_2, d_1$  are the distances from points 1 and 2 to the source of excitation;  $n_1, n_2$  are coefficients depending on the form of the wave front and dissipative forces. For the Caspian Sea the exponents  $n_1, n_2$  were found empirically.

In the present work it was assumed that  $n_1 = n_2 = 1$ , which corresponded to a point source with a spherical form of wave front. In this case the region of microseism excitation was somewhat expanded, but the location remained correct. The distance between seismic stations was chosen in such a way that the ocean region under investigation was inscribed within the arrangement of the stations.

Figure 1 shows plots of changes in amplitudes and periods over time for a number of seismic stations in the Atlantic basin for the period from 16 to 19 January 1958. We see that the stations Resolute, Pulkovo, Uppsala, Kiruna, and Apatity give synchronous changes in periods, i.e., the microseisms in them are excited by a single source. The Akureyri seismic station is not included in the construction; on 16-18 January it records its own frequencies, not synchronous with the other stations. From 18:00 on 18 January the De Bilt seismic station gives a sharp splitting

**Fig. 1.** January 1958. **1** –Pulkovo, **2** –Apatity, **3** –Resolute, **4** –Uppsala, **5** –Kiruna, **6** –De Bilt, **7** –Durham, **8** –Akureyri

of frequencies and also begins to record another source of excitation of microseisms. The change in amplitudes in this case, of course, does not change synchronously. During the construction it was found that some of the period curves (Fig. 1) are equidistant, which may be explained by dispersion phenomena.

**Fig. 2**

Such curves can also be used for the construction. At 00:00 and 06:00 on 16 January (Fig. 2), the location of the source of microseism excitation was carried out from the records of the seismic stations Resolute, Uppsala, Kiruna, and lies on the southwestern and western part of the cyclone. At 12:00 on 16 January all stations recording synchronous frequencies were used for the construction. The region of microseism excitation

expands and moves after the cyclone. At 18 hours on 17 I the cyclone turns southward and moves onto the continent. Subsequently the intensity of the process decreases, as is evident from the amplitude curve of the Resolute seismic

Fig. 3

Figure 3: Fig. 3

Fig. 4

Figure 4: Fig. 4

station (Fig. 1). For Kiruna and Apatity the record is complicated by the coastal effect, and possibly by the extent of the wave front.

Fig. 3

In Figs. 1 and 2 one can trace the cyclone that passed on 18 I at the level of  $62^{\circ}$  N, making landfall through Scandinavia. It is characterized by its own frequencies, which we identified at 18 hours on 18 I and 00 hours on 19 I from the stations

Fig. 4. December 1957. 1 –Resolute, 2 –Nord, 3 –Halle, 4 –Reykjavik, 5 –De Bilt, 6 –Durham

Akureyri, Durham, Uppsala. On 19 I, on the graph of microseism periods, three different processes are visible; they are led by the station groups Uppsala, Apatity, Kiruna ( $T = 6-7$  sec.), Durham, Akureyri ( $T = 5.5$  sec.) and De Bilt ( $T =$

$= 4.5$  sec.). These data are insufficient for locating the sources of excitation.

In Fig. 3, the arrow shows the movement of the cyclone on 7-8 XII 1957, which passed from west to east approximately at latitude  $55^{\circ}$  N. The location of the source of microseism excitation is shown from the Halle, Nord, and Resolute seismic stations. A clear picture of synchronism is visible in the period graphs (Fig. 4). At 18:00 on 7 XII the development of the microseismic storm had not yet begun. At 00:00, 06:00, and 12:00, large regions are visible which lag behind the closed isobars of minimum pressure of the cyclone. At 18:00 on 8 XII the cyclone is over land. The excitation region is obtained farther south, i.e., it may be assumed that the area of wave activity is increasing. The descending branches of the amplitude curves correspond to the time when the cyclone comes ashore. It has been noted that the location of the microseism source in this interval of time is somewhat uncertain. In the constructions it was impossible to use anomalous amplitudes in the records of the Reykjavik, Durham, and De Bilt stations (Fig. 4). The choice of seismic stations had to be made so as to avoid distorting effects caused by resonance of the underlying rocks (see, for example, <sup>(6)</sup>). Reykjavik records amplitudes up to  $100 \mu$ , while the nearby Icelandic stations Akureyri and Vik have amplitudes smaller by one order of magnitude. De Bilt and Durham do not conform to the law of decreasing amplitudes as a function of distance from the excitation source. Durham has amplitudes two times smaller than De Bilt, although, it would seem, the opposite should be the case.

Having examined considerable statistical material and compared intensities at different points, one can distinguish groups of seismic stations situated under identical geological conditions. This will help to refine further the location of the microseism source and provide information about the structure of the ground. In all constructions, standard microseism bulletins of various stations were used, without the application of any special apparatus.

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

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