Letter to the Editors

Microseisms in Alberta

(Received 1967 December 21)

Some aspects of Rayleigh wave propagation on the North American continent have been deduced from the observations of the directions of approach in the Alberta microseisms. The results are compared to work done elsewhere in North America.

The directions of approach were determined by means of a method developed by Jensen (1958). The method is based on particle motion analysis at a single station, and it yields the direction of approach of Rayleigh modes with retrograde particle motion, provided that such modes dominate the vertical recording. By means of an approximation formula given by Jensen (1961), the method also yields an estimate of the probable error of each single determination. This estimate will generally increase when there is interference from other waves, excepting Love waves from the same direction.

The directions of approach were determined from the long-period seismograms recorded at the University of Alberta seismograph station at Edmonton during 1963 July and August. The complete list of observations was given by Hjortenberg (1963). From this list Tables 1 and 2 were prepared. Table 1 presents the observations from the six isolated microseismic storms that occurred. Table 2 presents ten samples selected at random from the intervals between the storms. The tables show the range of measured periods, the distribution into octants of the directions of approach, and the probable error. Each probable error quoted is the largest estimate obtained.

Table 1

Numbers of observations of directions of approach at Edmonton. Microseismic storms, ordered according to their period range

<table>
<thead>
<tr>
<th>Date (1963)</th>
<th>Range of periods (s)</th>
<th>N</th>
<th>NE</th>
<th>E</th>
<th>SE</th>
<th>S</th>
<th>SW</th>
<th>W</th>
<th>NW</th>
<th>Octant error (deg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 22</td>
<td>4.0-4.4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>August 13</td>
<td>4.4-4.5</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>August 14</td>
<td>4.5</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>July 6</td>
<td>4.8-5.2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>August 28</td>
<td>5.2-5.8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>August 24</td>
<td>7.9-8.2</td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2

Number of observations of directions of approach at Edmonton. Randomly selected times between the storms

<table>
<thead>
<tr>
<th>Range of periods (s)</th>
<th>N</th>
<th>NE</th>
<th>E</th>
<th>SE</th>
<th>S</th>
<th>SW</th>
<th>W</th>
<th>NW</th>
<th>Octant error (deg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5-4.6</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>28</td>
</tr>
</tbody>
</table>
It is generally agreed that most 3–8 s period microseisms contain Rayleigh waves, and that their generation in general takes place over large bodies of open water. During July and August most of the microseism periods observed are in the 3–5 s range, and since the Pacific is the closest large body of open water, seen from Edmonton, it would be reasonable to expect that a substantial part of these 3–5 s period microseisms would be of Pacific origin. It is therefore remarkable that none of the directions of approach for such microseisms in the tables fall into any of the three western octants that cover the Pacific. This fact means that none of the 3–5 s period microseisms, listed in the tables, have a vertical component dominated by Rayleigh waves approaching from the West. It is therefore suggested that 3–5 s period Rayleigh waves are anomalously damped by the crustal structure between Edmonton and the Pacific. This structure includes the Rocky Mountains.

The absence of 3–5 s period observations in the western octants cannot be explained by quiet conditions in the Pacific. The weather maps were examined for the days of microseismic storms, and at July 22 and at August 13 high winds were present at the Pacific coast. On July 22 the weather conditions were quiet at other coasts.

Only in one case did Rayleigh waves of Pacific origin appear to dominate the microseisms in Alberta. This occurred on August 24 in a microseismic storm, which had a period of 8 s, well outside the range discussed above. These microseisms appeared to have an unusually low content of transverse waves, and they corresponded with a 30–40 h time lag to a meteorological storm at a distance of 700–1000 nautical miles from the coast. The fact that such microseisms appeared suggest that the 8 s period Rayleigh waves propagate well through the western mountain areas. This suggestion is in agreement with the result by Carder (1953) that the North American continent, parts of California excepted, is a good transmitter of 6–9 s period microseisms.

The July 6 and August 28 microseismic storms had 5–6 s periods and comparatively large amplitudes. Their northern approach directions corresponded to disturbed weather in the Canadian Arctic archipelago, and it is thus seen that 5–6 s period Rayleigh waves propagate well through the western parts of the Canadian Shield areas.

Using the LASA array, which is about 900 kilometres southeast of Edmonton, Lacoss (personal communication) has studied wavenumber spectra of the microseismic noise on the vertical component. At frequencies 0.2, 0.3 and 0.4 Hz he found fewer occurrences of low velocity (3–5 km/s) noise peaks from the West than from the East. He also found that these peaks for the noise from the East contained more power than those from the West. Moreover he found that the longer period noise arrived from both East and West without such a preference for the Eastern quadrants. The crustal structure to the west of LASA and of Edmonton thus seems to act as a frequency selective filter which strongly attenuate Rayleigh modes with frequencies of 0.2 Hz and above.

Acknowledgments

My thanks are due to Professor G. D. Garland, University of Toronto, to J. Hjelme, Geodetic Institute, and to Dr R. T. Lacoss, Lincoln Laboratories, M.I.T. These people have read the manuscript and have offered helpful suggestions.

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1967 December.
References


