pretation favorable to the junction of two great rivers. The bedrock has deep troughs, ridges, and islands that resemble the Bad Lands of the Dakotas rather than anything we might imagine around Boston. They could be meanders of the same river or the junction of several rivers. The seismic surveys were not extensive enough to determine which.

The supposed site of the pre-glacial Mystic River has been surveyed at several points in Medford, Malden, Charlestown, and Everett, Massachusetts. Points within the Medford-Malden Area appear definitely related to the original river-bed agreeing with the elevation of the pre-glacial Charles River. The region suggested in the past as the path of this river to the sea in the vicinity of Charlestown and Everett will have to be eliminated. Seismic surveys both on land and under water have shown that the bedrock is not of sufficient elevation to allow a gradient from the Medford-Malden Region to the sea.

Some work has been done by Weston College on Cape Cod in determining depth to bedrock. The surveys were preliminary and the extent of the region covered was not very great. A more complete survey is planned to take place as soon as circumstances permit.

A survey in cooperation with the Geological Society of America was made during the summer of 1941 in the Triassic formations of the Connecticut River Valley in Massachusetts. Again this survey was preliminary in character and no attempt could be made with the funds and time at the author's disposal for a continuous survey across the Valley. Certain points only could be chosen. In several of these locations, reflections from depths of several thousands of feet, believed to be the contact between the Triassics and the Paleozoic complex below, were obtained. At other points the condition of the sediments was such that shot-holes at depths of 25 feet and more were too loosely compacted to generate sufficient energy for suitable recording.

A few surveys have been carried on within the City Limits of Springfield, Massachusetts, to determine pre-glacial conditions there. An attempt was made in one or two places to find a possible ancient course of the Connecticut River, but without success; in other places the scouring effect of the glaciers on the soft sandstones especially along the erosion faces was studied.

Results obtained from the various problems have not been given in detail in this paper as they are of only local interest. The methods employed are standard and differ very little from those used in the petroleum industry and, although we have difficulties of operation such as density of population, shallow cover, high relief, etc., that the petroleum seismologist rarely encounters, there is little need of recounting them here. The variety of problems and the future of seismology as a prospecting device in New England is worthy of note. We feel, aside from the geological research ensuing from these studies, that there are many engineering problems as foundations for buildings and bridges, tunnels, damsites, etc., that could be benefited by employing seismologists to complement many of their drilling operations.

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A STATISTICAL STUDY OF THE PERIODS AND AMPLITUDES OF MICROSEISMS

James T. Wilson

It has been known for many years that the amplitude and period of the ordinary microseisms recorded at a given station vary from day to day and season to season. That the amplitude and period are greater in the winter than in the summer is also a recognized fact. However, the cause of the microseisms and the nature of their vibrations are not completely known. The present study is an attempt to obtain more information about the nature of microseismic waves.

In the early days of instrumental seismology it was concluded that microseisms were probably RAYLEIGH waves and this notion has persisted to the present. This conclusion was drawn primarily from the observation that the motion had a vertical component. It has seemed unlikely to the writer that the microseism-generating forces, whatever they may be, could set up RAYLEIGH waves without at the same time generating waves of other types.

Detailed studies by RAMIREZ [see 1 of "References" at end of paper] and KRUG [2] have shown that the microseismic movement is elliptical in both a horizontal and vertical plane. The motion in the vertical is retrograde in agreement with RAYLEIGH theory but the irregular elliptical motion in the horizontal can be explained on a RAYLEIGH-wave basis only by assuming waves arriving from more than one direction. This assumption may be perfectly valid but it needs further verification.

LEET [2], ARCHER [4], and BYERLY and WILSON [5] have studied the phase-relationships between the various components of motion. The work of ARCHER and that of BYERLY and WILSON gave some indication that RAYLEIGH waves were present. However, the preponderance

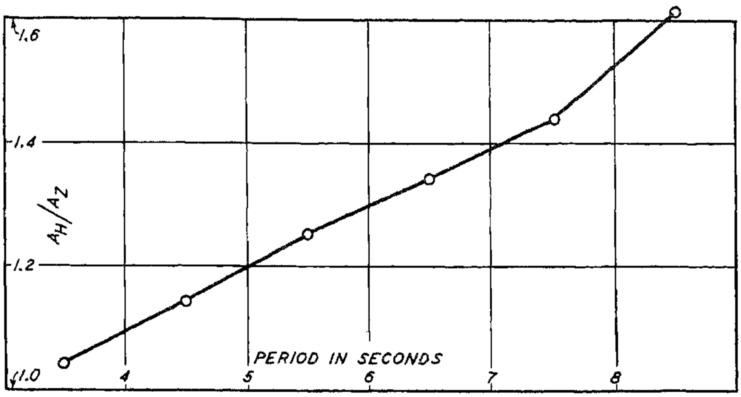

Fig. 1--Amplitude ratios, Berkeley microseisms, November 21, 1937, to November 21, 1938

of expected phase-differences was much smaller than it should have been for pure RAYLEIGH waves from one direction. Again this could be explained by assuming that the waves were arriving from several directions.

If microseisms are RAYLEIGH waves it would be expected that the ratio of the horizontal to the vertical amplitude would show a dependence on the period. The nature of the dependence would be controlled by the structure of the region. The relation between the amplitude-ratio and the period has been calculated by SUZUKI [6] and by LEE [7] for various cases.

Acknowledgment is hereby made of the assistance rendered by the personnel of the Work Projects Administration, Official Project 65-1-08-62, in securing measurements of the amplitudes and periods of microseisms recorded at Berkeley. The measurements have been made in several different ways but all of those made for the purposes of this study were of the largest amplitude and accompanying period in the ten-minute intervals centered on 8, 12, and 20 hours, Pacific standard time. The measurements were made on the three components of the Wilip-Galitzin instruments at Berkeley. These instruments have the same period and damping-factor and the horizontals have the same magnification while the vertical has a magnification of about 0.9 that of the horizontals.

The ratios of horizontal to vertical amplitude were formed by using the larger of the horizontal measurements. These ratios were then corrected for the difference in magnification between the vertical and horizontal components and tabulated according to the average period measured on the three components for that time. These data for the interval from November 21, 1937, to November 21, 1938, are summarized in Table 1.

Table 1--Amplitude-ratios of Berkeley microseisms for the interval, November 21, 1937, to November 21, 1938

Period in seconds	3-4	4-5	5-6	6-7	7-8	8-9
No. of observations	130	247	180	229	188	29
(A_h/A_z)	1.04	1.14	1.25	1.34	1.44	1.62

The average ratio of horizontal to vertical amplitude is 1.26 and the average period 5.63 seconds. The data of Table 1 are shown graphically in Figure 1. It can be seen that the ratio increases markedly with increasing period. Somewhat similar results have been shown by LEE for Uccle. However, his curve has a maximum at about six seconds and then decreases.

A comparison of the observed amplitude-ratios with those expected for the Berkeley Area

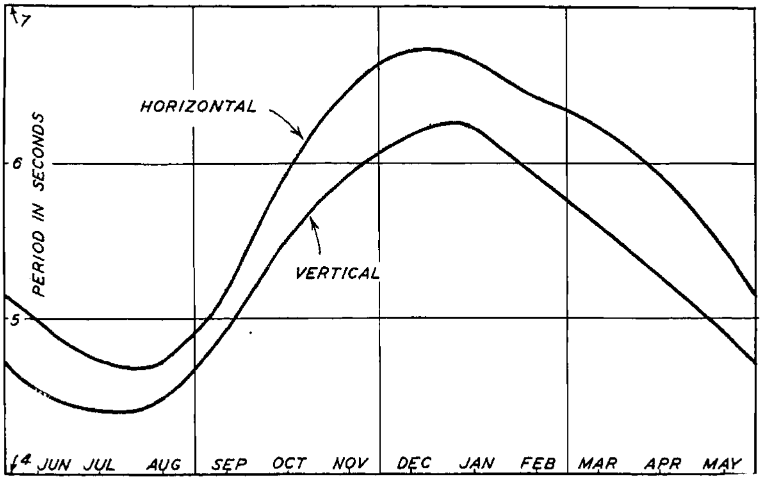

Fig. 2--Average period, Berkeley microseisms, November 21, 1937, to November 21, 1938

from the theoretical work of LEE and SUZUKI shows no agreement whatsoever. Taking the near-surface structure of the Berkeley Region to be that found by studies of the records of quarry-blasts [8] it would be expected that the ratio would increase from about 0.7 at three to four seconds to perhaps 0.9 for the longer periods.

From a study of quarry-blast records the near-surface structure in the region of Berkeley has been found to consist of a one- to two-km thick layer with a shear-wave velocity of 2.4 km/sec underlain by the normal granitic layer. To satisfactorily explain the observed ratios on the basis of the microseisms being pure RAYLEIGH waves a much thicker and much lower velocity-layer would be required. This is not compatible with either the blast-studies or the known geology of the area.

Because the amplitude-ratio data seemed to indicate that the microseisms might be a mixture of RAYLEIGH waves and some other wave-type with dominantly horizontal motion, the data were examined further. For example, the periods recorded on the horizontal and vertical components might be expected to differ by a detectable amount. The original measurements of period had been made to the nearest 0.1 sec with an error in the individual measurements of perhaps 0.2 sec. The periods measured on each component were averaged by months for the year under consideration. There were 80 to 90 measurements of period on each component each month. These data are summarized in Table 2.

Table 2--Average period of microseisms at Berkeley

Date	Component		
	Z	N	E
1937-38	sec	sec	sec
Nov. 21-Dec. 21	6.04	6.81	6.73
Dec. 21-Jan. 21	6.71	7.02	6.93
Jan. 21-Feb. 21	5.54	6.00	6.08
Feb. 21-Mar. 21	6.06	6.79	6.63
Mar. 21-Apr. 21	5.00	5.56	5.77
Apr. 21-May 21	5.35	5.85	6.03
May 21-June 21	4.26	4.72	4.72
June 21-July 21	4.53	4.90	4.84
July 21-Aug. 21	4.37	4.65	4.61
Aug. 21-Sep. 21	4.43	4.63	4.65
Sep. 21-Oct. 21	5.78	6.11	6.16
Oct. 21-Nov. 21	5.72	6.37	6.31
Grand averages	5.32	5.78	5.79

The data of Table 2 are shown by smoothed curves in Figure 2. The difference in period recorded on the vertical and on the horizontals is striking. It amounts to almost half a second on the average and is remarkably consistent throughout the year. The very close agreement between the average periods on the horizontals argues against errors in measurement by the observer and remeasurement by the writer verifies this. No records have been examined other than those from Berkeley but it seems unlikely that this is due to any instrumental peculiarity. However, this requires verification.

One obvious explanation of both the difference in period and the failure of the amplitude-ratios to agree with the expected values has already been suggested. If the microseisms are a mixture of LOVE and RAYLEIGH waves it would be expected that the ratio of horizontal to vertical amplitude would be increased. Furthermore, if the LOVE waves were of slightly longer period the apparent periods recorded by the horizontals would be longer than those recorded on the vertical. This mixture of waves would, of course, also explain the observed elliptical vibration in the horizontal plane.

This explanation is offered only as a tentative explanation and it is realized that much further work must be done before the nature of microseismic vibration is fully understood.

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PROGRESS-REPORT ON SEISMOLOGICAL ACTIVITIES OF THE UNITED STATES COAST AND GEODETIC SURVEY, APRIL 1, 1941, TO MARCH 31, 1942

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Teleseismic work--This was maintained with few exceptions on the same basis as in the previous year. (1) The privately operated station of Mrs. M. M. SEEBERGER at Des Moines, Iowa, resumed routine recording early in 1942. The records are being forwarded to the Coast and Geodetic Survey. (2) A McCOMB-ROMBERG seismograph was installed at the Spring Hill (Alabama) Seismograph-Station through the cooperation of The Franklin Institute and the Coast and Geodetic Survey. (3) WENNER seismometers for the Sitka Observatory were equipped with new coils, dynamic testers, and metal covers which can be oil-sealed; a one-component temporary instrument was in operation at the station during the alterations and a new recorder equipped with a WALLACE and TIERNAN motor modified for accurate control by a pendulum clock was placed in operation. (4) There was some cooperation with the National Park Service in connection with the establishment of a new station at Flagstaff, Arizona. (5) In cooperation with the International Seismological Association, photographic paper and paper for mechanical seismographs were supplied for the Danish stations at Ivigtut and Scoresby Sund, Greenland. (6) Four seismographs are now being operated in the Boulder Dam Area, one having been added in 1941; new stations are being established in the vicinities of Grand Coulee Dam and Shasta Dam; these projects are being conducted jointly with the Bureau of Reclamation and with the cooperation of the National Park Service.