BULLETIN OF THE EARTHQUAKE
RESEARCH INSTITUTE
Vol. 38 (1960), pp. 219-240

13. Observation of Surface Waves by Columbia-type Seismograph Installed at Tsukuba Station, Japan. (Part 1) — Rayleigh Wave Dispersions across the Oceanic Basin. —

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(Read Feb. 23, and March 22, 1960.—Received March 25, 1960.)

1. Introduction

As the Long-Period Seismology Program of the International Geophysical Year, Columbia University, U. S. A. installed the long period electromagnetic seismographs (15–80)[1] at many stations in the world. In Japan, this instrument was installed at Tsukuba Station, the Earthquake Research Institute of Tokyo University, and seismic observations have been continued since the beginning of 1958. Constants of this seismograph at Tsukuba Station are as follows:

Component	V_{max}	T_0	T_g	h_1	h_2	σ
EW	585	15.1	77	3.6	2.0	0.16
NS	610	15.1	97	3.6	2.1	0.16
UD	1460	15.0	104	1.5	2.1	0.15

in which, T_0: the natural period of Pendulum
T_g: ″ of Galvanometer
h_1: damping constant of pendulum
h_2: ″ of galvanometer
σ: coupling factor

This instrument could record many distant earthquakes and most of them showed clear surface waves (Fig. 1). The present work was done in order to see the differences between many dispersion curves of surface waves which travel through various paths around Japan. The epicenters, dates, and other data of shocks are given in Table 1, and their locations are shown in Fig. 2, together with travelling paths to Tsukuba Station.

1) G. SUTTON and J. OLIVER, "Seismographs of High Magnification at Long Periods", *Annales de Géophysique, t. 5, fasc.*, 4 (1959), 1.

As will be seen in the following many figures, we are lacking in the dispersion data for short period range. Therefore, the determinations of crustal structures in various regions must be postponed till the future. However, the abundant dispersion data due to as many as eighty shocks

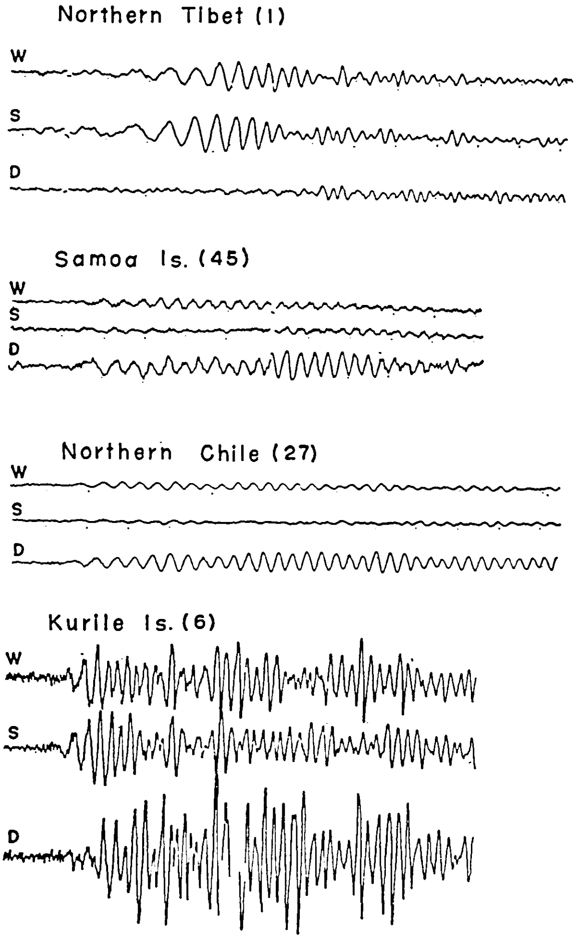


Fig. 1. Some examples of surface wave forms recorded by Columbia type seismograph.

gave us plenty of information about the qualitative features on the crustal structure of various regions around Japan. Besides, they offered us important problems to be studied.

In this first paper, only Rayleigh wave dispersions across the oceanic basin around Japan will be treated. Dispersion data were all taken on Z-component seismograms.

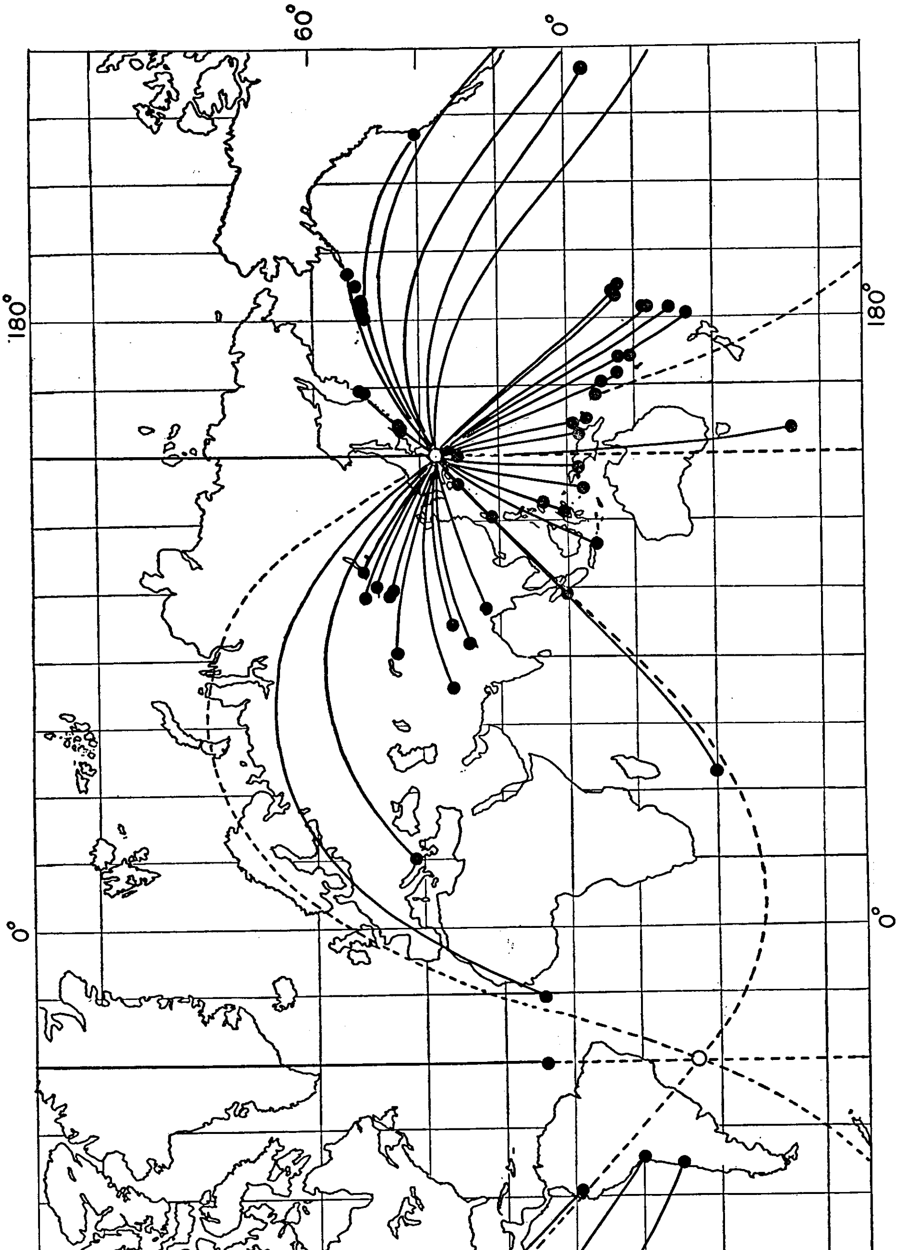


Fig. 2. Epicenters and travelling paths of surface waves. The paths represented by broken curves are those through which W_2 or W_3 were observed.

Table 1.

No.	District	Epicenter λ	φ	Date	Origin Time (G.M.T.)	Mag.
5	Kurile Is.	44N,	148.5E	Nov. 7, 58	$17^{h}\ 32^{m}\ 42^{s}$	
6	〃	44.5N,	149.5E	Nov. 7, 58	11 24 19	
7	〃	〃	149E	May 19, 59	19 35 08	
8	〃	〃	149.5E	Nov. 8, 58	19 14 31	
23	〃	46N,	151E	Sept. 9, 58	11 32 05	
24	〃	44N,	149E	Nov. 14, 58	05 34 53	
41	〃	44.5N,	147.5E	July 21, 58	07 24 58	6
35	〃	44N,	148E	Nov. 13, 58	02 56 26	
25	〃	〃	〃	Nov. 19, 58	17 52 52	
63	〃	44.5N,	148.5E	July 11, 59	18 23 00	
64	〃	44.5N,	150E	May 20, 59	19 35 08	
68	〃	44N	〃	May 9, 59	23 57 03	
79	〃	〃	〃	Nov. 19, 58	10 17 30	
80	〃	〃	148E	〃	17 52 52	
81	〃	〃	149.5E	Dec. 8, 58	12 08 23	
75	Kamchatka	53N,	160E	Oct. 10, 58	08 30 17	
78	〃	52N,	159.5E	Nov. 20, 58	05 36 33	
46	Aleutian Is.	52.5N,	170W	July 24, 58	13 08 05	
4	〃	51.5N,	176.5W	July 1, 58	05 53 07	6
42	〃	〃	176W	Aug. 16, 58	13 17 52	
49	〃	52N,	175W	Oct. 20, 58	00 55 34	
52	〃	51.5N,	178W	July 21, 58	05 53 07	
59	Northern Calif.	41N,	125.5W	July 24, 59	01 23 09	
27	Northern Chile	21S,	69W	July 11, 58	19 10 20	6.5
30	Chile-Argentin	33.5S,	65.5W	Sept. 4, 58	21 51 08	7
18	Pacific Ocean	5S,	106.5W	July 12, 58	00 48 30	
20	Ecuador-Peru	3S,	77W	May 25, 58	21 11 45	6.5
19	Marshall Is.	12N,	165E	July 12, 58	03 29 58	
17	Samoa Is.	15S,	174.5W	Apr. 22, 58	20 14 27	7
45	〃	16S,	172W	Nov. 16, 58	17 44 48	6
13	Tonga Is.	24S,	176.5W	Sept. 14, 59	13 15 49	
9	Kermadec Is.	29S,	177W	Sept. 14, 59	22 23 53	6.5
10	〃	〃	176.5W	Sept. 29, 59	15 31 57	6.5
11	〃	33.5S,	177.5W	Sept. 22, 58	19 05 44	6.5
12	〃	29.5S,	176.5W	Oct. 29, 59	14 19 51	6.5
60	New Hebrides Is.	16S,	172.5E	July 3, 59	17 55 29	6.5
61	〃	18.5S,	169E	July 11, 59	04 51 30	

(to be continued)

(continued)

No.	District	Epicenter λ	φ	Date	Origin Time (G.M.T.)	Mag.
					h m s	
15	Solomon Is.	10.5S,	161.5E	Aug. 24, 59	15 41 40	6.5
82	〃	〃	161E	〃	21 30 46	
83	〃	〃	〃	〃	23 32 23	
84	〃	〃	〃	〃	23 41 34	
53	〃	7.5S,	156E	Aug. 17, 59	21 04 40	7
3	New Britain	6S,	150.5E	Aug. 15, 58	02 26 51	
74	New Ireland	1S,	149.5E	Aug. 19, 58	21 48 07	
71	Bismark Sea	3S,	145.5E	Aug. 17, 58	18 01 05	
33	Antarctic Ocean	57S,	147E	Oct. 1, 58	09 29 43	6
72	Torishima	30.5N,	140E	Dec. 11, 58	15 33 25	
73	〃	〃	〃	〃	18 38 12	
21	New Guinea	3.5S,	135.5E	May 1, 59	07 19 16	
34	Banda Sea	6S,	131E	Nov. 14, 58	13 48 20	
56	Molluca Passage	2N,	126.5E	July 22, 59	20 15 33	
77	Mindanao I.	7N,	126.5E	Sept. 11, 58	18 01 45	
29	Java I.	9.5S,	112.5E	Oct. 20, 58	01 12 30	
28	Sumatra I.	2N,	98.5E	Oct. 12, 59	03 41 10	6
87	South Indian Oc.	40S,	45.5E	July 26, 58	06 13 50	
58	Formosa	23N,	121.5E	June 2, 58	19 13 30	
54	〃	〃	12E	Aug. 15, 59	08 57 04	7
26	Burma-Pakistan	23.5N,	94.5E	Mar. 22, 58	10 11 27	
32	Southern Tibet	30.5N,	85E	Oct. 28, 58	10 46 27	
39	Western Sinkiang	30.5N,	78.5E	June 24, 58	04 48 15	6.5
1	Northern Tibet	36N,	89E	Nov. 10, 59	20 56 12	
2	Afganistan	33N,	68.5E	May 19, 59	15 17 44	
38	Outer Mongolia	45N,	99E	Feb. 24, 58	12 27 06	
37	〃	46N,	98E	Apr. 13, 58	04 08 56	
70	Western Sinkiang	44.5N,	81E	Dec. 21, 58	05 46 26	
36	〃	51.5N,	99E	Apr. 10, 58	10 55 31	
55	Lake Baikal	52N,	106.5E	Aug. 29, 59	17 03 10	6.5
22	Albania	41.5N,	20E	Sept. 1, 59	12 00 39	6.5
76	Atlantic Ocean	9N,	39.5W	Sept. 25, 58	07 20 02	
66	〃	0.9N,	18W	June 7, 59	13 39 38	

2. Group velocity dispersion curves of Rayleigh waves for the paths in central, southern and south-western Pacific Ocean

There were several cases in which more than two dispersion data were obtained for the same travelling paths. Such examples are shown

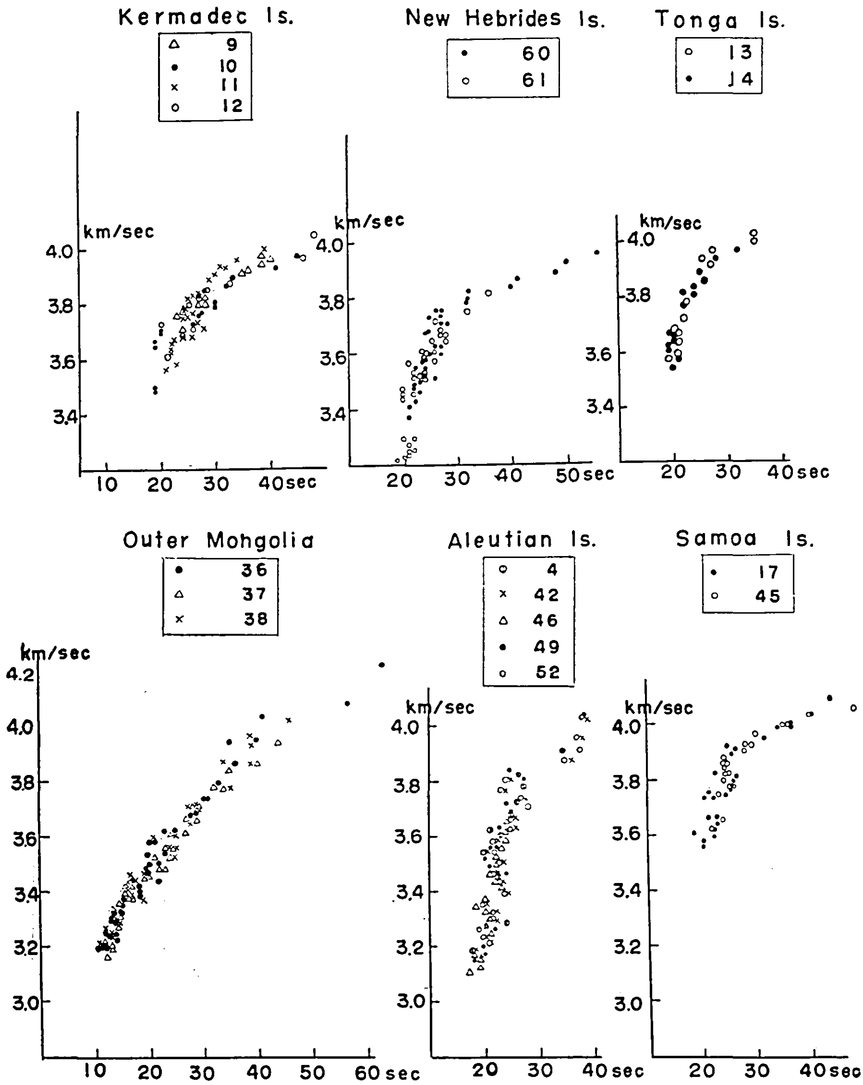
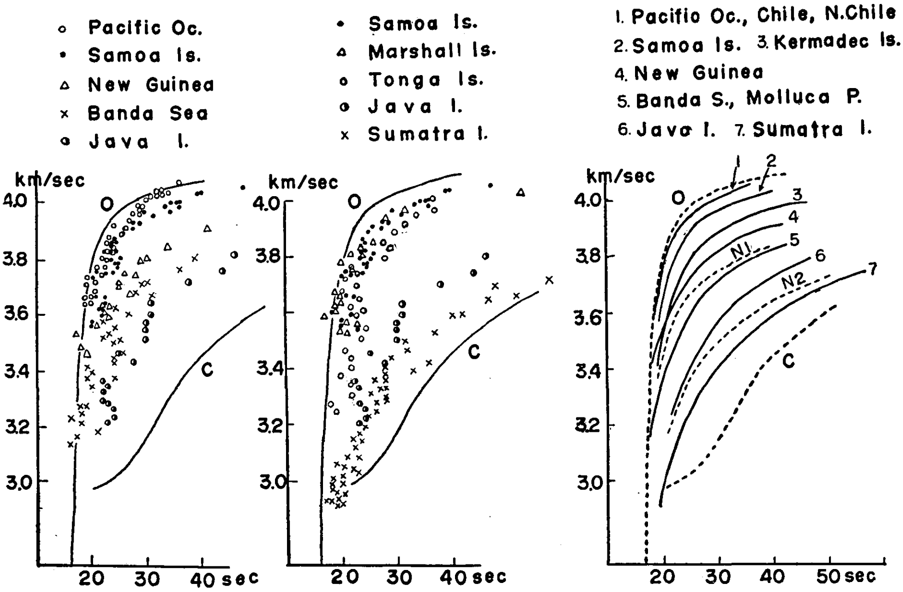


Fig. 3. Dispersions due to more than two shocks which occurred at the same district.

in Fig. 3. Of course, we cannot recognize the differences between the dispersive feature corresponding to each shock.



a b

Fig. 4a. Dispersions of various travelling paths through the central, southern and western Pacific Ocean. The typical dispersion curves for oceanic (O) and continental (C) paths are, for comparison, shown by solid curves.

Fig. 4b. Summarized results of smoothed dispersion curves for the central, southern and western Pacific Ocean paths. Beside O and C curves (the same as in Fig. 4a), two curves N_1 and N_2 which were observed by Nagamune for southern and western paths are represented for comparison.

Fig. 4a shows the dispersions obtained by the shocks represented above them. Replacing by continuous curves, they are summarized in Fig. 4b. In this figure, four dispersion curves are also shown for comparison. *O*-curve, the uppermost one, is a theoretical dispersion curve of W.S. Jardetzky and F. Press[2] for oceanic paths with the structure as the right figure,

h	α	ρ
5.3 km	1.52 km/sec	1.0
5.3 〃	6.90 〃	2.67
∞	8.1 〃	3.00

in which, h, α and ρ mean the thickness, the velocity of *P*-waves, and

2) W. S. JARDETZKY and F. PRESS, "Crustal Structure and Surface Wave Dispersion, Part III; Theoretical Dispersion Curves for Suboceanic Rayleigh Waves," *Bull. Seism. Soc. Amer.*, [ii], **43** (1953), 137.

the density respectively. The lowermost curve C is the observational continental curve which the present writer[3] found for the paths from

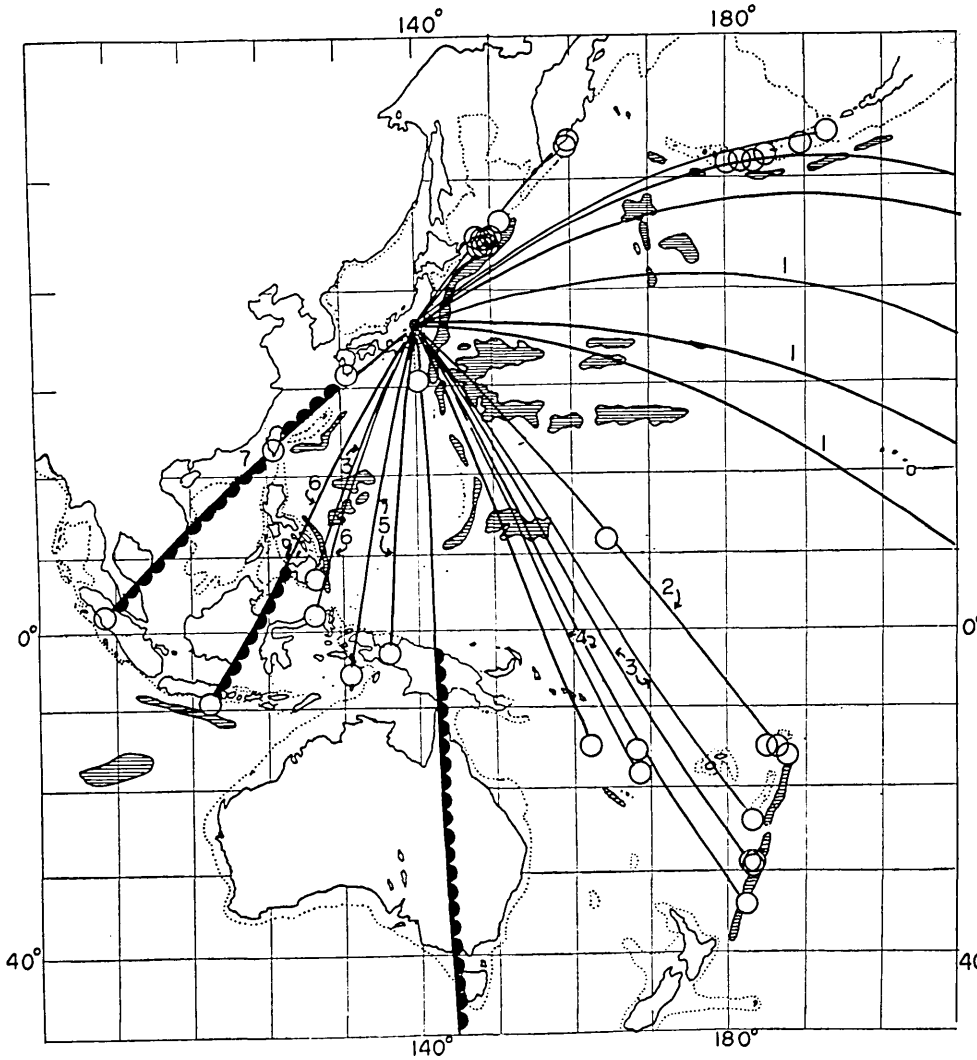


Fig. 5. Detailed map which shows the epicenters and travelling paths of Rayleigh waves for oceanic basin around Japan. Dotted lines are contour lines for the water depth of 1000 m, and the regions with horizontal lines are deep sea regions of more than 6000 m in depth. The paths indicated by the series of semi-circles mean those for which the dispersion curves were computed by subtractions.

3) T. AKIMA, "On Dispersion Curves of Surface Waves from the Great Assam Earthquake of August 15, 1950," *Bull Earthq. Res. Inst.*, **30** (1952), 237.

Assam district to the south-western Japan. Other two curves "N_1" and "N_2" are also the observational ones obtained by T. Nagamune[4] for

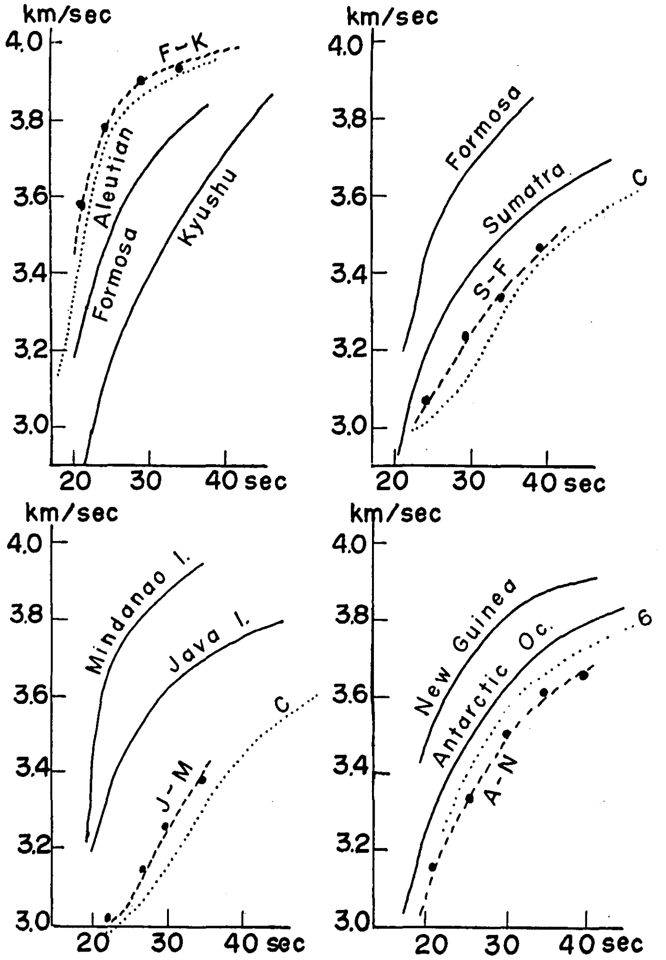


Fig. 6. The dispersion curves (broken lines) derived from the two dispersion curves (solid lines). The dotted dispersion curves of another shocks are represented for comparison with the resultant curves.

the paths from the region of Solomon Islands and from the region of New Guinea or Selebes Islands to central Japan respectively.

Fig. 4b shows us an interesting fact that these dispersion curves,

4) T. NAGAMUNE, "On the Travel Time and the Dispersion of Surface Waves (III), *Geophys. Mag.*, [i], **27** (1956), 93.

approach to the continental one as the corresponding travelling paths shift westward. This tendency is also shown in Fig. 5, in which the numerals beside each travelling path correspond to the respective dispersion curve in Fig. 4b. There is only one travelling path, from Mindanao Island to Japan, which does not obey the general tendency. It means that the crustal structure beneath the region along this path is rather oceanic in western Pacific Ocean. As this path is occupied by the deep sea region (See Fig. 5), this exceptional result may be reasonable.

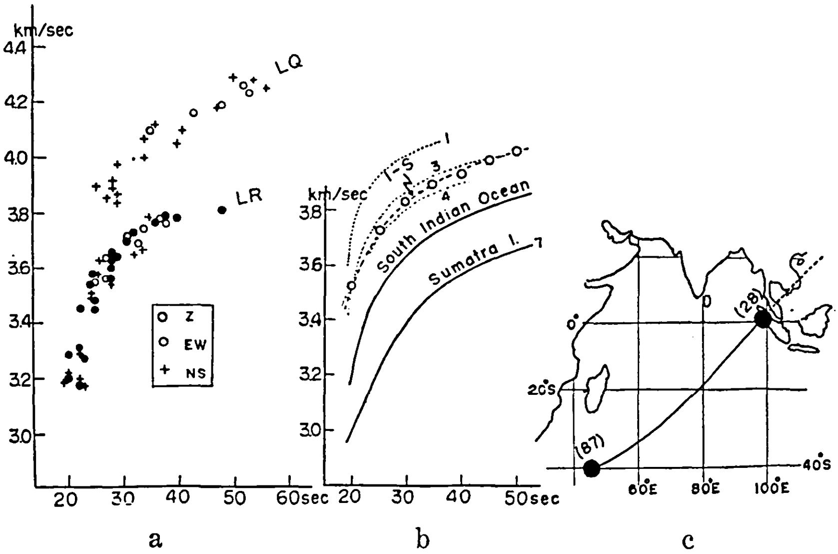


Fig. 7a. Dispersions of Love (LQ) and Rayleigh (LR) waves due to South Indian Ocean shock (87).

Fig. 7b. Dispersion of Rayleigh waves calculated from those of South Indian Ocean and Sumatra Island shocks. "3" and "4" are the dispersion curves due to Kermadec Islands and New Guinea shock respectively.

Fig. 7c. Travelling path of Rayleigh waves from the epicenter of the South Indian Ocean shock (87) to that of the Sumatra Island shock (28).

There are several favourable cases in which the travelling path of the surface waves occupies a part of the path for another shock. In these cases, we can easily subtract the travel-time of surface waves and obtain a new group velocity dispersion curve for this remaining path. Broken curves in Fig. 6 are all such resultant dispersion curves, and corresponding paths are shown in the previous map (Fig. 5) by the mark like a warm front.

These results tell us that the crustal structures from Sumatra Island to Formosa and from Java Island to Mindanao Island are both continental, while that from the Antarctic Ocean to New Guinea is not so continental. Considering that approximately 60% of the path is the Australian Continent, we must suggest that the remaining part (Antarctic Ocean south of Australia) is oceanic and its crust is very thin.

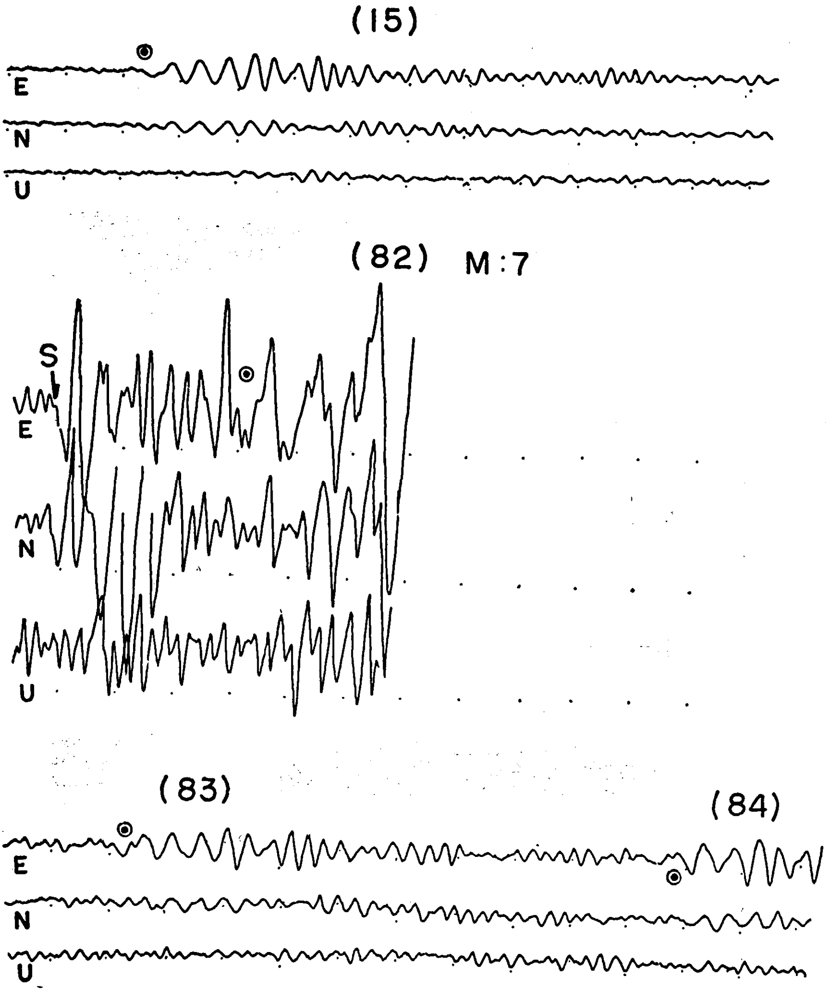


Fig. 8. Seismograms of Solomon Islands shocks which did not sent out Rayleigh waves. Double circles in horizontal records show the beginnings of Love waves.

Further, by subtracting the travel time due to Sumatra Island shock from that due to South Indian Ocean shock, we can obtain an information about the crustal structure beneath the region shown in Fig. 7c. The resultant dispersion character represented by white circles in Fig. 7b differs from the curve 1 (for the central Pacific Ocean) but is rather similar to the curve 3 (for Kermadec Islands shocks) or 4 (for New Guinea shocks).

There was an interesting phenomenon for the surface waves due to

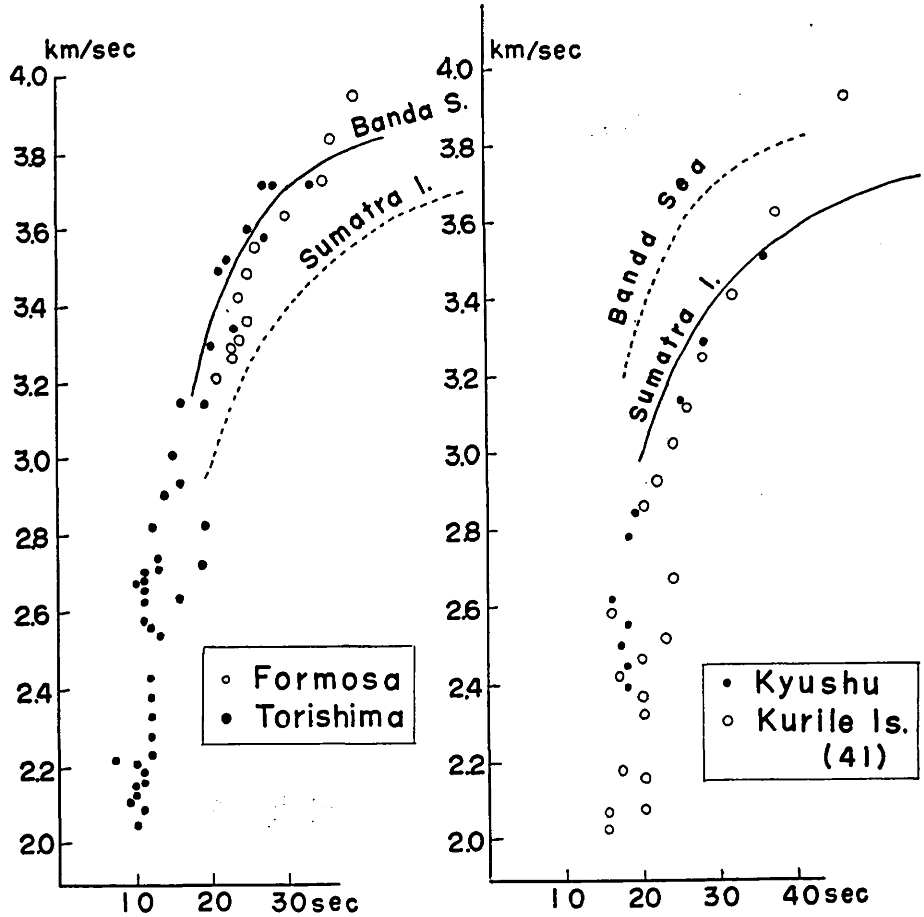


Fig. 9. Dispersions due to the Formosa, Torishima, Kyushu and Kurile Islands (41) shocks.

Solomon Islands shocks. On August 24, 1959, four shocks took place in the Solomon Islands. (See Table 1). The wave forms are partly shown in Fig. 8. The interesting fact is that, as is well seen in this figure, there are no dispersive wave forms in all of the Z component seismograms. (The onsets of P waves were as remarkable as any other shocks and the travel-time of P_n were also normal.) That is, these four Solomon shocks sent out remarkable Love waves, but not Rayleigh waves.

Is it possible to assume such mechanism of P wave generation at the origin that sent out P_n but not Rayleigh waves to a certain direction? This must be studied in the future.

Another type of dispersion curves, which we call type "B" in this paper, was discovered. This type differs from the former one that we call here type "A" which was summarized in Fig. 4b. As is recognized in Fig. 9, the dispersion curves due to Formosa, Kyushu and Torishima shocks show steep inclinations compared to those due to Banda Sea and Sumatra Island shocks belonging to the former type "A".

As will be shown in the later sections, the dispersive characters of Rayleigh waves which travel along the paths from Aleutian Islands, southeast coast of Kamchatka, Kurile Islands, Mariana Islands, etc., to the central Japan show the same feature as this type "B". It must be noticed that all of these paths belonging to this "B" type, without any exceptions, lie near or over the series of volcanic islands which is lined with the trenches.

3. Dispersion of Rayleigh waves across the paths along and quite near the Kurile Trench

Many shocks took place near Kurile Islands. (Fig. 10). Dispersions of Rayleigh waves due to fifteen of them were investigated. In spite of rather compact distribution of their epicenters, the dispersive characters differ very much.

Only seven of them showed such regular features as are seen in Fig. 10. There is a fact to be noticed, that the dispersion due to the shock 41 only shows the special feature quite different to the remaining ones. Besides, this curve is quite similar to that for the shock 32, which took place at the south-eastern coast of Kyushu. As is well seen in the annexed map of Fig. 10, only the epicenter of the shock 41 is located quite near the Island, and the travelling path to Tsukuba is farthest from Kurile Trench.

As the dispersion curves obtained are limited to those of narrow period range, we cannot determine the crustal structure along this travelling path at present. However, the fact given above must be kept in mind as an interesting fact to be solved.

The middle dispersion curve (Fig. 10) corresponds to the shocks 63, 7 and 64, which are located nearer to the Trench. This curve is similar to that of the shock 72 which took place at Torishima. The last curve,

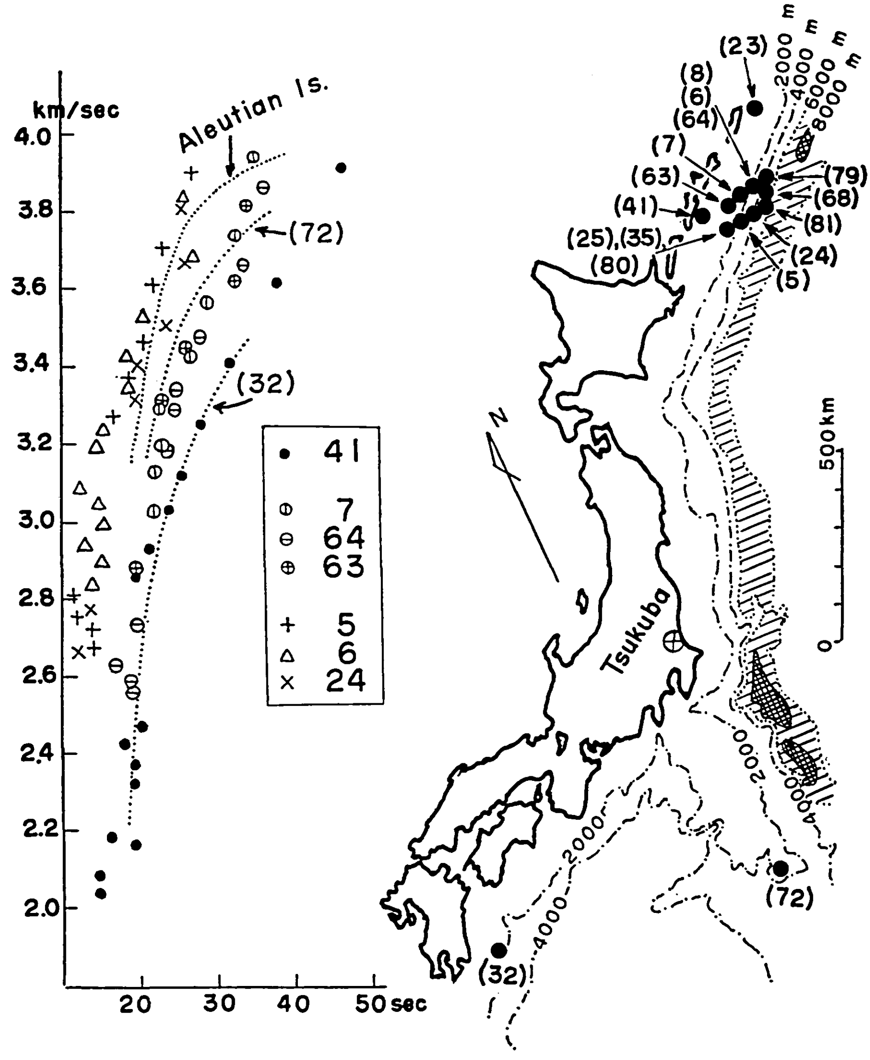


Fig. 10. The epicenters of Kurile Islands shocks and their dispersions. Dispersion curves due to Kyushu (32), Torishima (72) and Aleutian Islands shocks are also represented for comparison.

the leftmost one, corresponds to the shocks 5,6 and 24, and these epicenters are located quite near the Trench. The dispersive characters for the remaining eight shocks were so diverged that the writer could not draw smoothed curves.

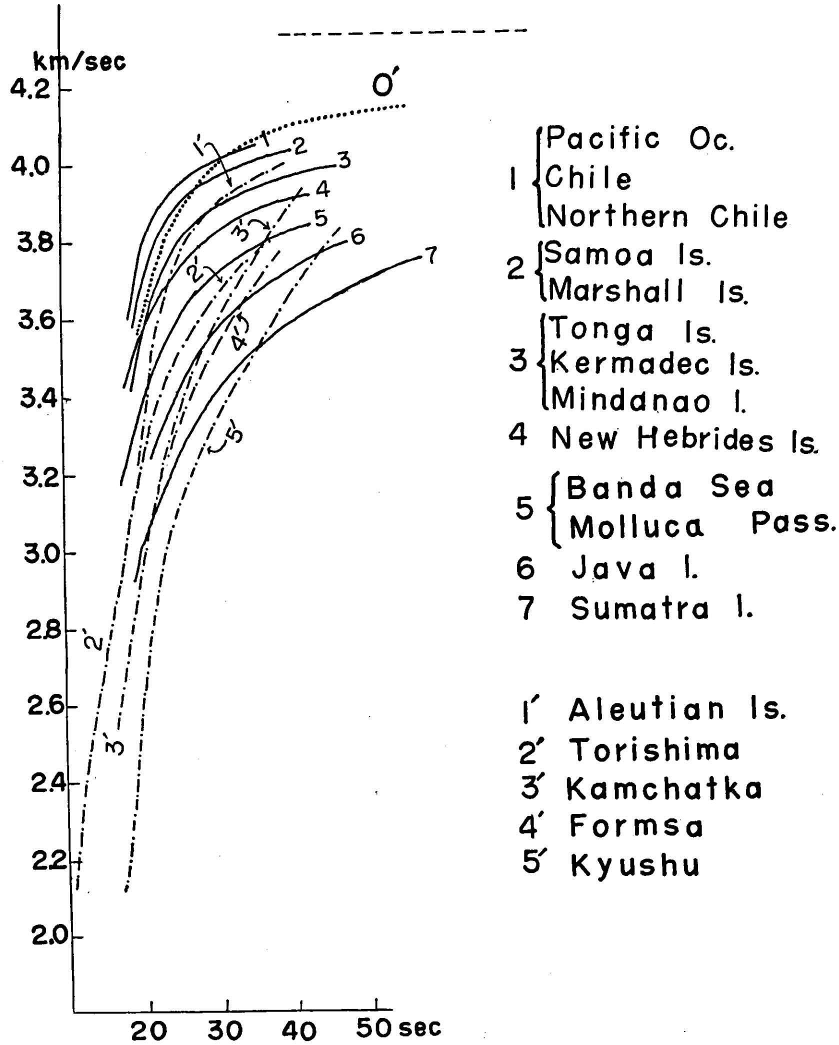


Fig. 11. Summarized dispersion curves of Rayleigh waves for various oceanic paths around Japan. Nagamune's observed curve for northern Pacific Ocean path[5] is given by O' curve. Horizontal broken line means the symptote line of Rayleigh wave velocity for α (the velocity of P-waves under the Mohorovičić discontinuity)=8.1 km/sec.

5) T. NAGAMUNE, "On the Travel Time and the Dispersion of Surface Waves (III): Dispersion of Surface Waves and Structure of North and Central Pacific Basins," *Geophys. Mag.*, [i], **28** (1957), 1.

The above feature of special dispersive character for Kurile Islands shocks is based, undoubtedly, upon the exceptional condition beneath the sea bed near or in the Trench. What makes the dispersive feature so abnormal? Why dispersion curves differ so much in spite of the closely gathered epicenters? There remain many interesting problems to be explained.

4. Dispersion of Rayleigh waves due to the shocks around Bismark Islands

We have seen two kinds of dispersion curves of Rayleigh waves with oceanic paths around Japan. The first one ("A" type) was for the travelling paths through the general oceanic basin such as central, southern and southwestern Pacific Ocean or Indian Ocean, and the second one ("B" type) was for the paths near or over the series of volcanic islands beside the trench. These two kinds of dispersion curves are summarized in Fig. 11, in which solid and broken curves correspond to the "A" and "B" types respectively.

For the reason given above, three shocks around Bismark Islands (New Ireland (74), Bismark Sea (71) and New Britain (3)) are quite interesting ones. For, the travelling paths of Rayleigh waves due to these three shocks partly cover the Mariana Islands region (See Fig. 12b). This region has the similar geological and geographical conditions to the regions through which Rayleigh waves show the dispersive feature of "B type".

Considering the circumstances stated above, we can expect that the dispersion curves due to these three shocks may be composed of two types of dispersions "A" and "B". Fig. 12a shows the observed dispersions due to these three shocks. As is seen in this figure, they lie around one smooth curve as if these points were all obtained from a single shock. Moreover, just as we have expected, the dispersion character belongs neither to the "A" nor the "B" type and seems to be influenced by both of them.

Seeing the travelling paths due to these shocks (See Fig. 12b), they can be divided into two parts. The first is from the epicenters to the southern edge of 2000 m sea depth contour line which envelopes Mariana Islands and the second is the remainder parts which contain the series of volcanic islands such as Mariana, Volcano and Bonin Islands. The dispersion of Rayleigh waves through the first and the second part will belong to the "A" and "B" type of dispersion respectively. Namely, Rayleigh waves will travel the first part (approximately 36% of the total path) with the group velocities determined by "A" type dispersive character and then travel the remaining second part by "B" type dispersion. Therefore, by selecting a suitable pair of dispersion curves, one from its "A" type and the other from its "B type", we can make a composite dispersion curve which is similar to the observed one.

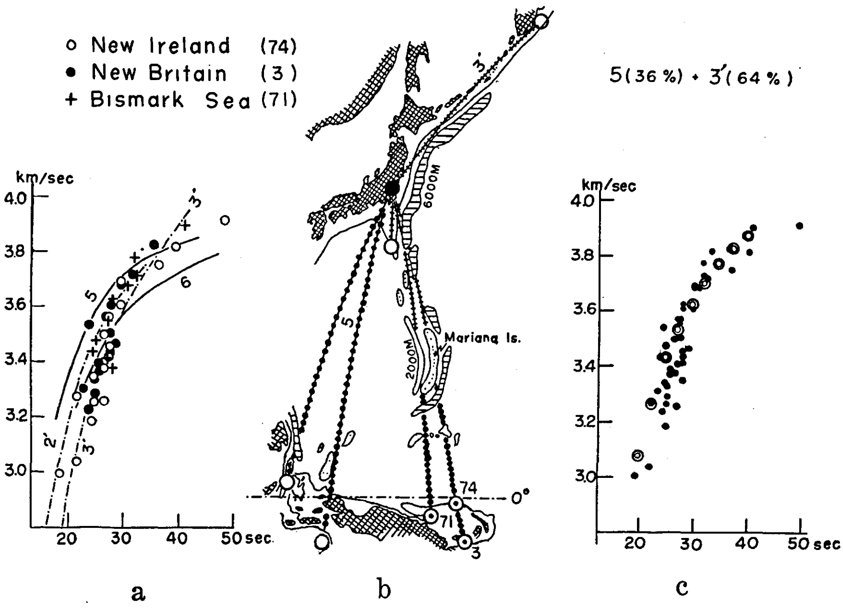


Fig. 12a. Dispersions of Rayleigh waves due to the three shocks around Bismark Islands. Dispersion curves of "5" and "6" (belong to the type "A") and of "2′" and "3′" (belong to the type "B") were also represented for comparisons.

Fig. 12b. Travelling paths of Rayleigh waves due to the three shocks (3, 71 and 74) around Bismark Islands together with those due to Kamchatka, Banda Sea and Molluca Passage shocks. Contour lines of Sea depth are 2000 m. The regions with horizontal hatched lines are trenches. Paths through which Rayleigh waves show the similar dispersion are distinctively represented.

Fig. 12c. The resultant dispersion curves by the composition of two curves "5" and "3′".

The results are shown in Fig. 12c represented by double circles. In this figure, the observed data for the three shocks are all represented by black circles. Though there is a little departure in short period range, this result tells us that the dispersion of Rayleigh waves due to the three shocks around Bismark Islands is well explained by the composition of "5" and "3′" which belong to the "A" and "B" type respectively. In other words, the crustal structure from the epicenters to Mariana Islands are, in average, similar to that from Molluca Passage or Banda Sea to central Japan, and the region of Mariana, Volcano and Bonin Islands has the similar crustal structure to the region from southeast coast of Kamchatka (through Kurile Islands and side of Japan Trench) to central Japan.

5. Dispersion of surface waves due to the Atlantic Ocean shock

The Atlantic Ocean shock (76) which took place on September 25, 1958 was very interesting for our study. Because this epicenter (9°N, 39.5°E) was located approximately north of the antipode of Tsukuba Station, surface waves due to this shock passed through the north pole or the south pole.

Fortunately, the Columbia-type seismograph could record the surface waves which passed both the north pole (minor travelling path) and south pole (major travelling path). Fig. 13 shows the travelling paths of surface waves around north and south pole respectively. In the same figure, we can see the dispersion of Love and Rayleigh waves together with that of W_2 (Love waves along the major arc).

As is also shown in this figure, the dispersions of both Love and Rayleigh waves along the minor arc coincide very well with those of the Antarctic Ocean shock (33). The travelling path of the (33) shock contains the continental part of approximately 47%. It is interesting, on the other hand, that if we assume the crustal structure of Greenland and Arctic region to be purely continental and oceanic respectively, the travelling path of Rayleigh waves due to the Atlantic shock (76) contains the continental part of approximately 49%, which is nearly the same as the former. J. Oliver and others[6] investigated the crustal structure of the Arctic region from the *Lg* phase and found that the Greenland and Arctic regions have continental and oceanic crustal structure respectively. From the present results just obtained, we can make the same suggestion.

Fig. 13 also shows the dispersion data of W_2. As the data of these waves are limited to long period range, we cannot compare them well with that of Love waves data for minor travelling paths. However,

6) J. OLIVER, M. EWING and F. PRESS, "Crustal Structure of the Arctic Regions from the Lg Phase." *Bull. Geol. Soc. Amer.* **66** (1955), 1063.

they look like to lie on one dispersion curve. In this case also, the travelling path contains 44% of continental part, if we assume the Antarctic region along the path to have purely continental structure.

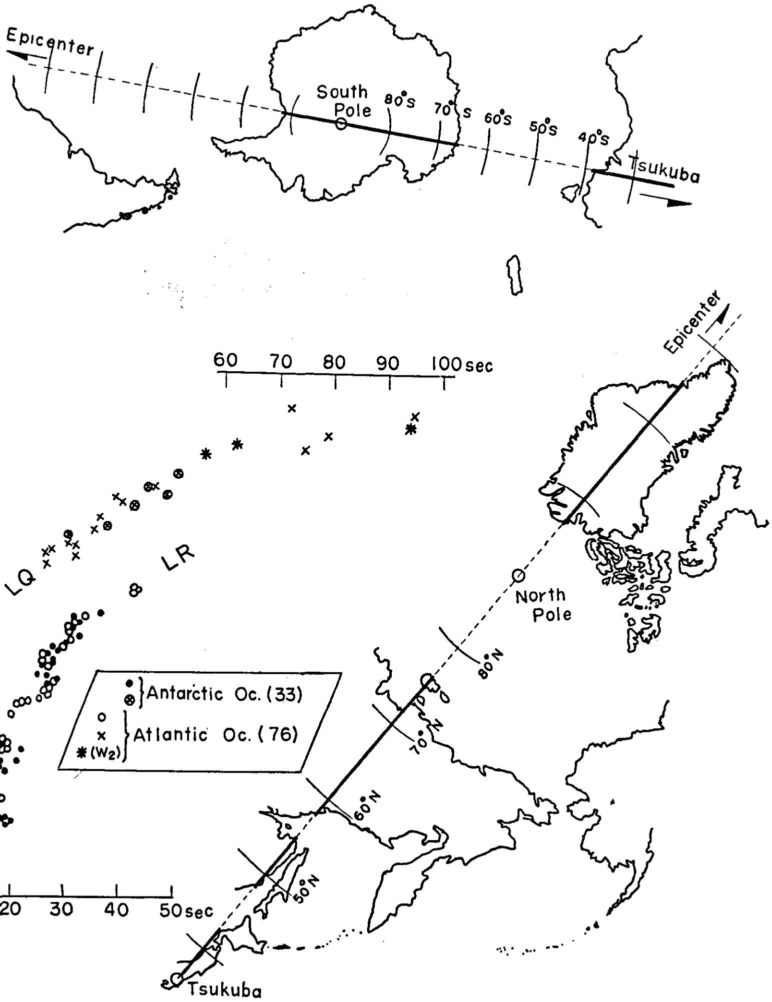


Fig. 13. Dispersions of surface waves due to the shocks (33) and (76). The annexed maps show the travelling paths of LQ, LR and W_2. Solid lines show the continental parts along the paths.

This value is quite similar to the former two. From this result, we may suggest that the Antarctic region has, at least along the present travelling path, a continental crustal structure. This suggestion is consistent with the results obtained by C. R. Bentley and others[7] by gravity observations.

The writer shows in Fig. 14, for reference, how the dispersion curves of Love and Rayleigh waves change with the percentage of purely continental part among their travelling path. The data of dispersions we treated above lie between 40% to 50% lines. From this result,

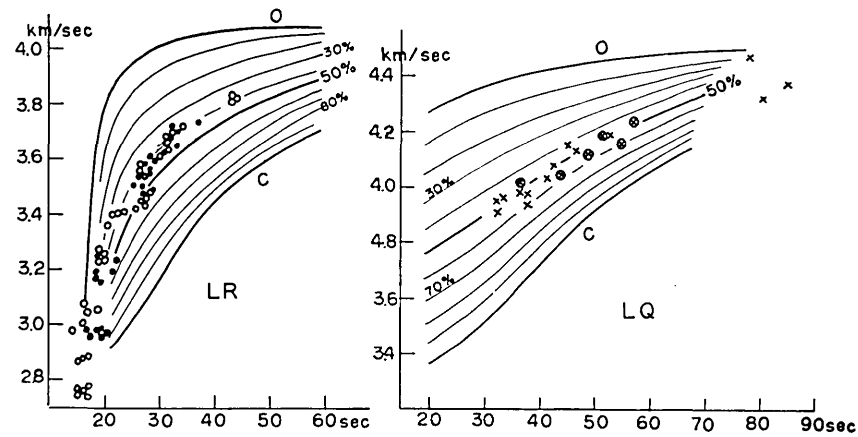


Fig. 14. Shifts of dispersion curves with the percentage of purely continental part. Dispersion points are the same as those of Fig. 13.

we may say that the similarity of the surface waves dispersions for the Atlantic shock (76) with those for Antarctic shock (33) is caused from the purely continental and purely oceanic crustal structure of the Greenland and Arctic region respectively.

6. Conclusions

Installation of Columbia-type long-period seismographs, which have good response to the periods of surface waves, enabled us to investigate the group velocity dispersions of surface waves which travelled across various paths around Japan.

In this first paper, only dispersion data of the Rayleigh waves across oceanic paths were treated, nevertheless, not a few noticeable facts were discovered. That is:

1) In the south-western Pacific Ocean, the Rayleigh wave dispersion curve becomes more continental for the western region. It means that

7) C. R. BENTLEY, A. P. CRARY, N. A. OSTENSO and E. C. THIEL, "Structure of West Antarctica," *Science*, **131** (1960), 131.

the crust of the earth beneath the Ocean becomes, in average, thicker for the western Pacific Ocean.

2) Rayleigh waves could not be observed for several Solomon shocks which took place at the same place on August 24, 1959. One way to explain this phenomenon must be sought for the special generation mechanism of P waves.

3) Several local crustal structures could be estimated as follows:

a) The region from Sumatra Island to Formosa and from Java Island to Mindanao Island have both thick crust.

b) Beneath Ryukyu Islands, the crustal structure resembles to that from Aleutian Islands to central Japan.

c) The crust at the Antarctic Ocean south of Australia is quite thin.

d) The dispersion of Rayleigh waves through the Indian Ocean is not similar to that of through the central Pacific Ocean, but rather similar to the western Pacific Ocean.

4) On the case of fifteen Kurile Islands shocks which took place near the Kurile Trench, most of the dispersion data of Rayleigh waves were very widely spread. We could obtain the ordinary dispersion curve for only seven of them.

Further, they were divided into three kinds, remarkably different from each other. The first one, corresponding to the shock farthest from the Trench, is quite similar to that due to the shock of Kyushu. The second one, corresponding to three shocks which are a little nearer to the Trench, is similar to that due to the shock of Torishima and Formosa. The third one for three shocks, having the epicenters much nearer to the Trench, is similar to that due to the shocks of Aleutian Islands.

5) All of the dispersion curves for the paths over or near the series of volcanic islands beside trenches show remarkable different character from those for the paths over the other oceanic basin.

6) From the similarity of dispersion curves of both Love and Rayleigh waves for Atlantic Ocean shock (76) and for Antarctic Ocean shock (33), the crustal structure of the Arctic zone and Greenland are considered to be purely oceanic and continental structure respectively. Antarctic region along the longitude of 40°W to 140°E may have continental structure.

7) The crustal structure of the South Indian Ocean differs from that of the central Pacific Ocean. It is similar to the southern Pacific

Ocean (the region from Kermadec Islands or New Guinea to central Japan).

7. Acknowledgements

In conclusion, the writer wishes to express his hearty thanks to Lamont Geological Observatory for permission to use the seismograms obtained by the Columbia seismographs installed at Tsukuba Station.

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13. コロンビア型地震計による表面波の観測 (第一報)
——海洋底を伝わるレーリー波の分散——

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I.G.Y. 期間中の遠地地震観測計画の一つとして，アメリカのコロンビア大学では，振子および検流計の固有周期がそれぞれ15秒および90秒前後の長周期電磁式地震計を世界の 10 数カ所に設置したが，そのうちの一台が地震研究所の筑波支所に置かれて，1958 年初頭から常時観測が開始されて今日におよんでいる．この地震計によつて，非常にたくさんの表面波が記録され，現在までに約 80 ケの地震の表面波の分散を調べることができた．しかも，それらの表面波の伝播径路は，日本を中心としてほとんどあらゆる領域を占めている (第 2 図)．第 1 報では，このうち，海洋底を伝わつてきたレーリー波の分散の様子だけについて述べるが，径路が多岐にわたつているだけに，予想以上にいろいろの注目すべき結果が得られ，また今後の研究を必要とする問題点も出て来た．すなわち，

1) 海溝に沿つてならんだ火山性列島付近を通つてくるレーリー波の分散曲線を多数調べたが，何れも普通の海洋底を通つてくるレーリー波の分散曲線とは明瞭に区別できる一群の曲線群を形成する (第 11 図)．これ等の曲線群を説明するためには，特別な速度分布を地殻に与える必要が起るかも知れない．
2) 南太平洋の部分については，地震波の径路が西に移るにつれて，分散曲線は次第に陸型に近づいてゆく (第 4 図 b)．
3) エトロフ島沖の地震群に限つて，分散がひどく乱れる．また，明瞭な分散曲線を示した地震についても，震央が僅かに海溝よりから島よりに移つただけで，その分散の様子がひどく変化する．これ等の地震は，その震源もまたそれらによるレーリー波の伝播径路も，海溝から火山列島への狭い漸移地帯中にはさまれている点が注目される (第 10 図)．
4) P_n 波や S 波やラブ波などは明瞭に記録されたが，レーリー波だけが記録されなかつた地震がソロモン群島で 4 ケあつた (第 8 図)．
5) 観測点からほぼ同じ方向にあつて，しかも震央距離がかなりちがつた二つの地震によるレーリー波の分散曲線を使つて，周期毎に走時を差引くことにより，残つた区域に関する分散曲線が作れる．この方法で若干の地域の平均的な地殻の厚さの質的な推定をしてみると，
   a) スマトラ島から台湾，ジャワ島からミンダナオ島に至る範囲の地殻は厚い．
   b) 琉球列島の地殻構造は，アリューシャン列島から中部日本に至る部分のそれと似ている．
   c) オーストラリヤ大陸南部の海洋の地殻はきわめてうすい．
   d) インド洋南部の地殻の厚さは，中部太平洋よりはやや厚く，南部太平洋なみである(第7図b)．
6) 径路が丁度南北両極を通過する表面波の分散曲線が，南極洋の地震のそれとほとんど一致することを利用して (第 13 図)，北極が海であること，グリーンランドと南極が陸であることを認めた．
