

1. Rayleigh Wave Dispersions across the Oceanic Basin around Japan (Part III).

—On the Crust of the South-Western Pacific Ocean—

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1. Introduction

In the two previous papers,^{1),2)} the writer studied the dispersion of Rayleigh waves which travelled along various oceanic paths to reach Japan. One of the important facts we obtained was that the dispersive character of Rayleigh waves changes gradually from an oceanic to a continental one when the travelling paths change northwest to south around Japan. Geographically speaking, the dispersive characteristics were almost uniform and purely oceanic for the paths across the region where neither oceanic island nor atoll exists, while they showed a slight difference from the oceanic when the path runs through the Polynesia or Micronesia region which contains "the rashes" given above. Further, when a section of the path entered the western side, the continental side of the "Andesite line",³⁾ the departure of the dispersive character of Rayleigh waves from the oceanic became marked and at last they became purely continental for the westernmost path, from Sumatra Island to Japan. The abundant dispersion data were classified into seven groups, numbered from 1 to 7 in the order from the purely oceanic to the continental type. From the geographical and the geological point of view, the following two factors seem to bring about a decrease in the group velocities of Rayleigh waves and therefore change the dispersion curves from oceanic to continental ones; that is, (i) the ex-

1) T. A. SANTÔ, "Observation of Surface Waves by Columbia-type Seismograph Installed at Tsukuba Station, Japan (Part I).—Rayleigh Wave Dispersions across the Oceanic Basin—," *Bull. Earthq. Res. Inst.*, **38** (1960), 237.

2) T. A. SANTÔ, "Rayleigh Wave Dispersions across the Oceanic Basin around Japan (Part II)," *Bull. Earthq. Res. Inst.*, **38** (1960), 385.

3) H. H. HESS, "Major Structural Features of the Western North Pacific. An Interpretation of H. O. 5485, Bathymetric Chart. Korea to New Guinea," *Bull. Geol. Soc. Amer.*, **59** (1948), 417.

istence of "the rashes" on the ocean floor such as oceanic islands, atolls or Guyots, and (ii) the continental crustal structure in the western side of the "Andesite line" in the western Pacific Ocean.

These suggestions may be affirmed by re-examining the dispersion data obtained by J. E. Oliver et al.⁴⁾ They studied the dispersions of Rayleigh waves which travelled along various paths to Hawaii. Plotting their data on our group velocity \sim period diagram (our velocity scale to period scale is ten times larger than that in their paper), it was clarified up that these data also lead to the same conclusions (Fig. 1). That is, the Rayleigh waves which travelled the non-island region from the Marianas, Kuriles or Chile to Honolulu show the No. 1 dispersive characteristics according to our characteristic numbers, while they show the No. 2 characteristics owing to the shocks of the Solomons, Tongas or southern Japan, the paths of which contain oceanic islands. Rayleigh waves owing to the Formosa or Luzon shocks give Honolulu Station such dispersive characteristics as No. 3 or No. 4 according to our characteristic numbers, the paths of which enter deeply the continental side of the "Andesite line."

Then, what kind of crustal conditions at or around the "rashes" on the oceanic basin or around the "Andesite line" bring about a lowering in the group velocities of Rayleigh waves?

The main purpose of this third paper is to discuss this point, and to give some information about the crustal conditions in the western side of the "Andesite line", especially in and around the Philippine basin and Melanesia region, which is one of the most anomalous structures and has been inaccessible to geophysical research.

2. The relation between the sea depth and the dispersive feature of Rayleigh waves

In order to compare our observed dispersion data with the theoretical curves for some crustal models, it is desirable to know the average depths of the sea water which covers the crust along each path.

For this purpose, topographies of the sea bed along all of the travelling paths were examined. Some examples are shown in Fig. 2. The average sea depths (\bar{D}) along the paths were measured from these

4) J. E. OLIVER, M. EWING and F. PRESS, "Crustal Structure and Surface-Wave Dispersion, Part IV. Atlantic and Pacific Ocean Basins," *Bull. Geol. Soc. Amer.*, **66** (1955), 913.

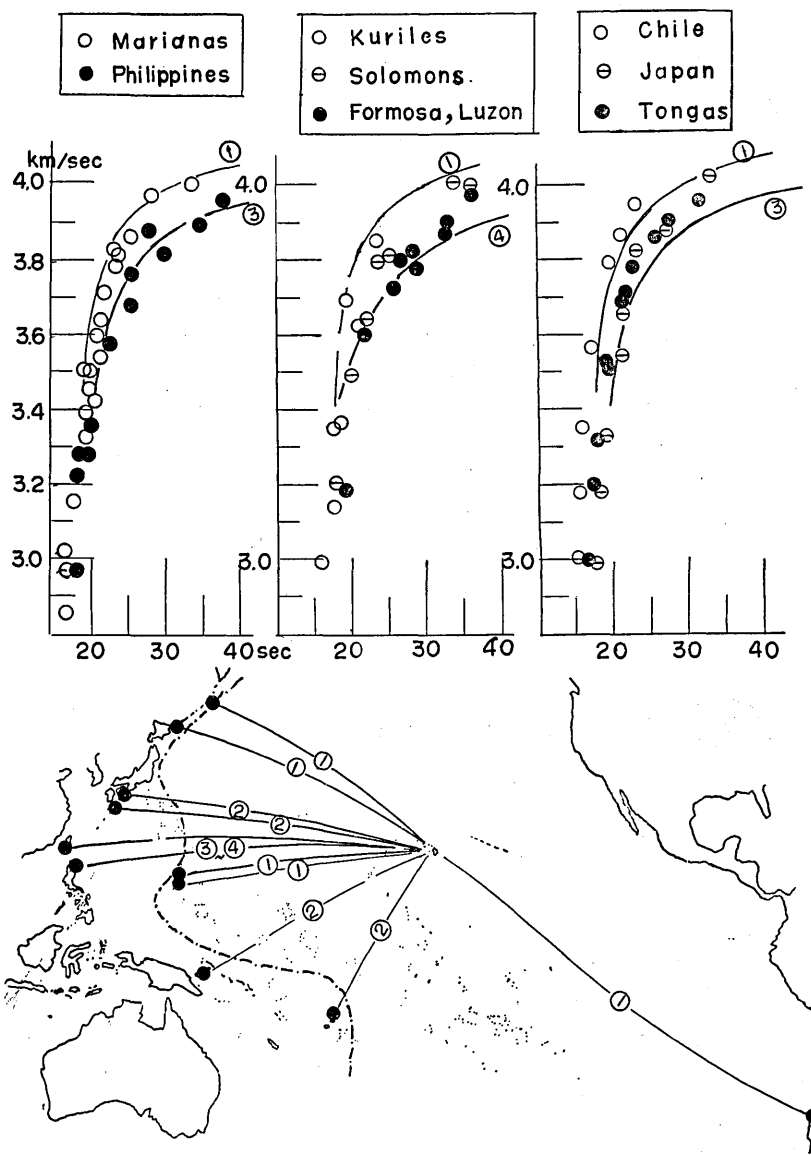


Fig. 1. Dispersive features of Rayleigh waves observed at Hawaii by J. Oliver et al. Original data were re-plotted on the new diagrams in which the ratio of the velocity scale to the period scale is ten times larger than the original one. Our classified dispersion curves and their corresponding characteristic numbers are given for comparison.

--- Andesite line.

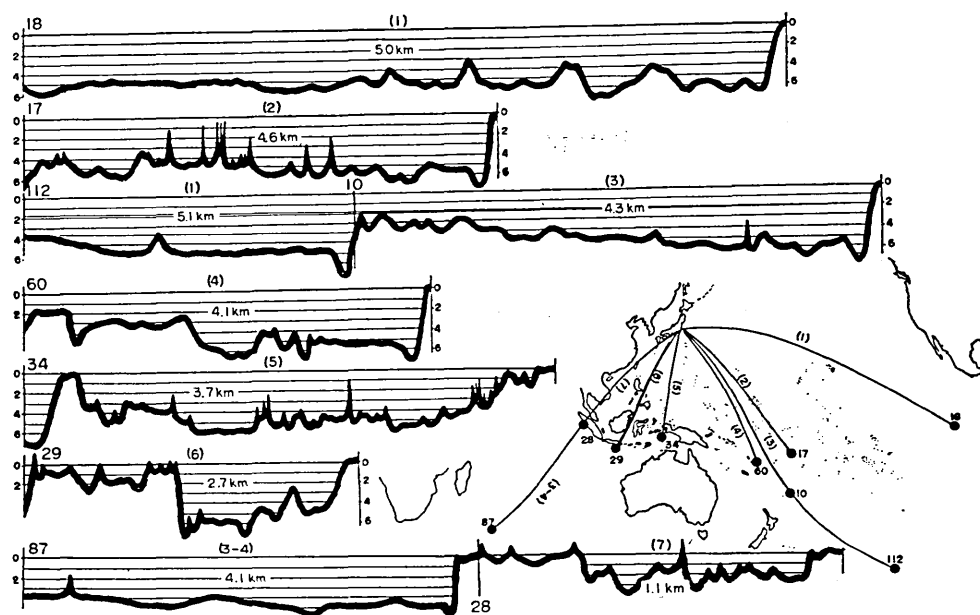


Fig. 2. Several examples of the topographies of the sea bed along the paths which are shown in the annexed map. The vertical scales are all exaggerated about 170 times as are the horizontal ones. The characteristic numbers of Rayleigh wave dispersions along each path are given in brackets.

profiles, the results of which are given in the fourth column of Table 1.

From the data in the third and fourth columns in this Table, we can study the relation between the average sea depth (\bar{D}) and the characteristic number (N) of Rayleigh wave dispersions. The results are shown in Fig. 3, in which the ordinate is the characteristic number N plotted at intervals approximately proportional to the spacing of each numbered curve in our velocity~period diagram. In the fifth column of Table 1, the percentages of oceanic (geographical) path lengths to the total are given. These values along almost all the paths are greater than 90%, but those for several paths in the lower ranks are remarkably small. Therefore, the data of \bar{D} and N for these paths (represented by white marks in Fig. 3) must be shifted somewhat leftward (e.g., towards smaller characteristic numbers) if we subtract the travel-times for the continental part and make the dispersion curves for almost oceanic paths.

Before we discuss these results, it must be noticed that the observ-

Table 1.

No. of shocks	District	<i>N</i>	\bar{D}	%
30	Chile-Argentin border	1	4.56	100
18	Pacific Ocean	1	5.01	99
59	Northern California	1	4.78	98
27	Northern Chile	1	4.92	99
112-11		1	5.02	100
104	Galapagos Islands	1	4.28	99
124	Peru	1	4.54	100
105	Drake Passage	2	4.08	99
131	Chile	2	4.30	100
139	Eastern Islands	2	4.58	100
17	Samoa Islands	2	5.05	99
112	South Pacific Ocean	2	4.60	100
113-60		2	4.47	100
19	Marshall Islands	2	4.60	100
113	South Pacific Ocean	3	4.28	100
128	Fiji Islands	3	4.43	99
125	Helmahera Islands	3	4.19	96
116	Santa Cruz Islands	3	4.15	99
77	Mindanao Islands	3	4.45	92
13	Tonga Islands	3	4.25	97
10	Kermadec Islands	3	4.30	99
87-28		3	4.10	97
60	New Hebrides Islands	4	4.07	99
121	Solomon Islands	4	4.38	99
138	Norfolk Islands	4	3.47	99
134	South Island, New Zealand	4	3.39	97
111	"	4	3.74	98
126	New Guinea	4	3.54	91
21	"	4	3.31	95
114	Ceram Islands	4	3.77	94
34	Banda Sea	5	3.70	92
56	Molluca Passage	5	4.06	97
111-121		5	2.60	96
101	Celebes Island	5	3.61	85
90	Balleny Islands	6	2.29	78
33	Antarctic Ocean	6	1.85	63
29	Java Island	6	2.26	85
28	Sumatra Island	7	1.11	69

The last column means the percentage of the length of the oceanic paths.

ed variation of the dispersive characteristics indicated by numbers from 1 to 7 cannot be explained by the single effect of the variation of sea water depth. For, if the crustal structure beneath the water is the same and only the water depth varies, the dispersion curve must vary almost horizontally as is shown in Fig. 4. This is quite different from

the observed one. As will be shown in the later section, the variation of the dispersion curves from 1 to 7 can be explained by changing the crustal properties

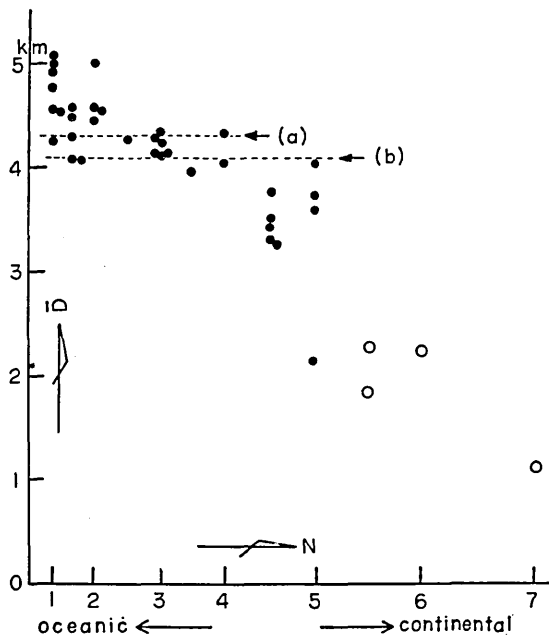


Fig. 3. The relation between \bar{D} (the mean sea depth along the path) and N (the characteristic number of dispersive features). The white circles mean the data for which the path contains more than a 10% continental (geographical) part.

beneath the water into more continental ones. Therefore, we may say from the results in Fig. 3 that, on the average, the crustal structure becomes oceanic with the increasing sea depth.

There is another noticeable fact, that is, many points with values of \bar{D} between 4.0 km and 4.3 km show especially large horizontal scattering. For instance, the characteristics numbers of the dispersion for several points around a dotted line (a) ($\bar{D}=4.30$ km) change from 1 to 4, and those around (b) ($\bar{D}=4.10$ km) from 2 to 5.

This fact means that there are peculiar regions in which the crustal structure differs remarkably in spite of an almost similar average water depth.

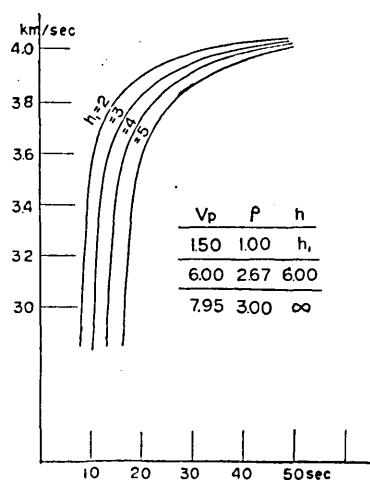


Fig. 4. Rayleigh wave dispersion curves for various depths of sea water over the same crustal structure.

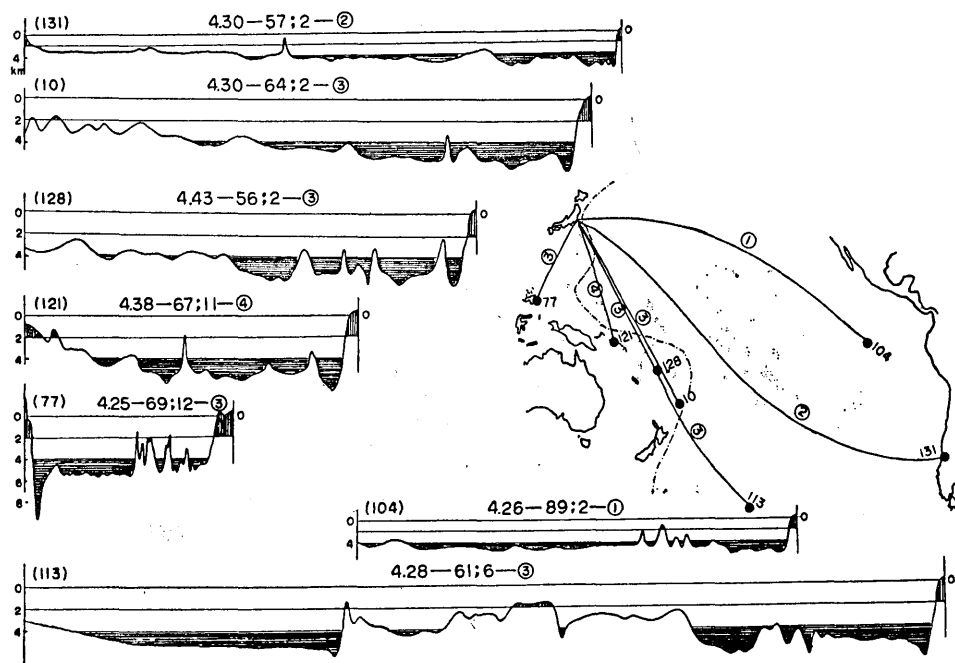


Fig. 5-a. Travelling paths and the profiles of the sea bed along the paths for which the data around (a) line in Fig. 3 were obtained. In each profile, the numbers in the brackets are the shock numbers. The values of \bar{D} , the percentage of D_1 , D_2 and the characteristic number N are represented in this order above each profile. All the vertical scale of the profiles are exaggerated about 170 times as are the horizontal ones.

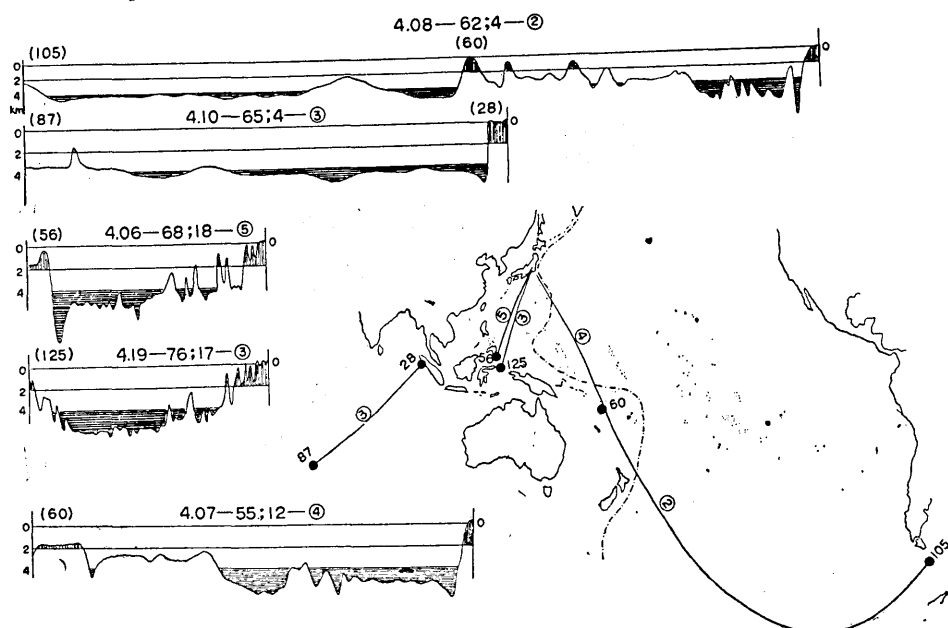


Fig. 5-b. The same as Fig. 5-a for the data around (b) line in Fig. 3.

It has been found from *Lg* phase observations⁵⁾ that the crust is typically continental in any large area where the water depth is less than about 2 km, and typically oceanic for water depths greater than 4 km. Based upon this conclusion, it was at first suggested that these anomalous results in Fig. 3 might be caused by different percentages of D_2 (the path length along which the water depth is lower than 2 km) or of D_4 (the path length along which the water depth is deeper than 4 km) to the total path length along these paths.

This suggestion was examined. Figs. 5-a and 5-b respectively show the profiles of oceanic basins along the paths for which the anomalous data were obtained. These paths are also shown on the maps in the same figures. From these profiles, the values of \bar{D} , D_4 and D_2 were all measured, and the results are also given at the top of each profile.

The results are disappointing. The difference in the dispersive features depend neither upon the values of D_4 nor D_2 . As an example, let us compare the first case (for shock (131)) with the second (for shock (10)) or the third (for shock (128)) cases in Fig. 5-a. Though \bar{D} , D_4 and D_2 are all approximately the same, the dispersive features of Rayleigh waves along the path due to shock (131) (belonging to 2) differs from the two others (both belong to 3). The similar fact can be recognized by comparing the cases of shocks (121) and (77) in the same figure, and between (105) and (87), (56) and (125) in the next figure 5-b.

Then, what makes the dispersive feature of Rayleigh waves so variable along these paths? As will be shown in the later section, the change from 2 to 4 or 5 cannot be explained only by the thickening of the crust, but can be explained by the decreasing of the wave velocities in the crust. Based upon the fact that many volcanic islands or atolls exist in these regions, a suggestion can be given, that the observed variations of dispersions in these regions may be explained by a lower mean velocity of the crust as a results of the presence of a layer of volcanic rock.

This suggestion is demonstrated in Fig. 6. In this figure, three models of crustal structure A, B and C are presented. M. N. Hill⁶⁾ summarized the results of refraction measurements for the oceanic

5) M. EWING and F. PRESS, "Geophysical Contrasts between Continents and Ocean Basins," *Crust of the Earth. Special Paper 62, Geol. Soc. Amer.*, (1955), 1.

6) M. N. HILL, "Recent Geophysical Exploration of the Ocean Floor," *Physics and Chemistry of the Earth, Vol. 2* (1957), 129.

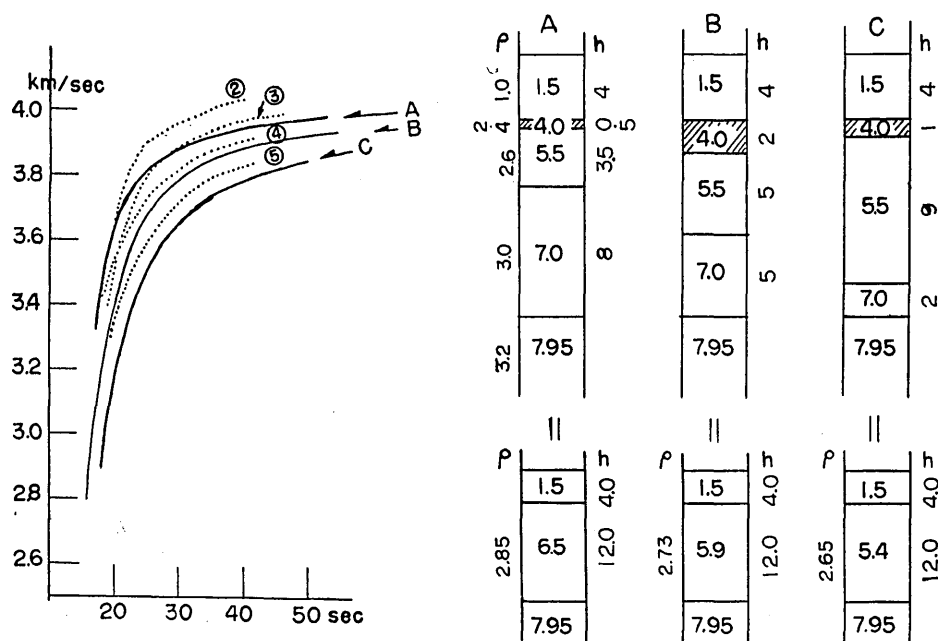


Fig. 6. This figure demonstrates that the dispersive character of Rayleigh waves greatly varies with the presence of a layer of volcanic rock of varying thickness (hatched layer).

basins and gave the following standard crustal model for oceans deeper than 4.0 km. The velocity of the compressional waves α in each layer in our models A, B and C was based on a reference to his model.

Layer	α (km/sec)	h (km)
Sea water	1.5	4.5
1. Unconsolidated sedimentary layer	2 (1.5~2.5)	0.45
2. Volcanic or consolidated sediments	4~6	1.75
3. Basaltic rock	6.71 (6.4~7)	4.7
4. Ultra basic rock	7.09 (7.9~8.4)	∞

Since in our three models A, B and C, the second, third and fourth layers themselves are so thin for wave lengths of Rayleigh waves with periods greater than 20 seconds that we may suppose that observed Rayleigh waves will be dispersed as if the crust were of such equivalent structure as is shown just below the individual models. The velocities of compressional waves α , densities ρ and thicknesses h of

each layer in the simplified equivalent models were calculated from H. Jeffreys' theoretical formula given for the case of Love waves.⁷⁾ He proved that as far as the dispersion of Love waves is concerned, such a doubly stratified crustal structure as (A) is equivalent to such a single-layered crustal structure as (B) shown below, when the wave length is much longer than h_1 and h_2 :

$$\begin{array}{ccc}
 \text{(A)} & & \text{(B)} \\
 \hline
 \beta_1 \quad \rho_1 \quad \mu_1 \quad h_1 & = & \beta'_1 \quad \rho'_1 \quad \mu'_1 \quad h'_1 \\
 \beta \quad \rho_2 \quad \mu_2 \quad h_2 & & \beta_3 \quad \rho_3 \quad \mu_3 \quad \infty \\
 \beta_3 \quad \rho_3 \quad \mu_3 \quad \infty & &
 \end{array}
 \quad \text{where} \quad \beta'_1 = \left(\frac{\mu_1 h_1 + \mu_2 h_2}{\rho_1 h_1 + \rho_2 h_2} \right)^{1/2},$$

$$\rho'_1 = \frac{\rho_1 h_1 + \rho_2 h_2}{h_1 + h_2} \quad \text{and} \quad h'_1 = h_1 + h_2.$$

(β : Velocity of shear waves).

These relations have been extended neither to the threefold-, fourfold-, ... etc. crustal structures nor to the Rayleigh waves. However, we may adopt this formula in the present case without significant error.

The calculated dispersion curves of Rayleigh waves through three kinds of such equivalent layers are given by the solid curves in Fig. 6. In this figure, we can recognize that the shifting of the theoretical dispersion curve caused by the addition of a sedimentary layer of varying thickness (marked by oblique lines) is quite similar to the ones actually observed (dotted curves). From these results, we may suggest that the observed variation of the dispersive character in such an anomalous region as was given in Fig. 5 may be caused by the decrease of the mean velocity of compressional waves in the crust due to the presence of a layer of volcanic rock in the oceanic islands region. This suggestion will further be affirmed in the next section.

3. Comparison of the observed dispersion curves with theoretical curves

It was suggested in the earlier part of this paper that the existence of "rashes" in some ocean floors may affect the dispersion of the Rayleigh waves which travel across it. Then, what kind of physical property in the crust at or around these rashes affects the dispersion of Rayleigh waves?

In order to answer this question, the observed dispersion curves

7) H. JEFFREYS, "The Effect on Love Waves of Heterogeneity in the Lower Layer," *Mon. Not. Roy. Ast. Soc., Geophys. Suppl.*, **2** (1928), 101.

numbered from 1 to 7 were compared with some theoretical dispersion curves. The results are given in Figs. 7-a, -b and -c, in which the wave paths are also shown in the lower maps. The models of the crust corresponding to the theoretical dispersion curves A, B, C, D and E are respectively as follows:

A			B			D		
α	ρ	h	α	ρ	h	α	ρ	h
1.52	1.00	5.57	1.50	1.00	5.30	1.50	1.00	4.20
7.95	3.00	∞	6.90	2.57	5.30	6.00	2.80	12.6
			8.10	3.00	∞	7.95	3.00	∞

D			E		
α	ρ	h	α	ρ	h
1.50	1.00	3.70	1.50	1.00	2.00
6.00	2.80	15.0	5.00	2.80	15.0
7.95	3.00	∞	7.95	3.00	∞

The procedure usually adopted in determining the crustal structure along the travelling path of surface waves by the group velocity method is to find out the most suitable crustal model for which the theoretical dispersion curves best fit the observed data. But, this procedure will not be adopted here for the following two reasons: (1) The crustal structure cannot be uniquely determined without using two kinds of surface waves, Love and Rayleigh waves.^{8),9)} (2) Even if we can observe the dispersions of both Love and Rayleigh waves, the determined crustal structure by the group velocity method is but an average one along the path. Therefore, the result is significant only when the surface waves travelled along an almost uniform crustal structure. Considering that the oceanic region in and around the Philippine basin and Melanesia is one of the most anomalous regions with rapid lateral variations in its structure, the usual method may lose its significance for these regions.

8) Y. SATÔ, "Study of Surface Waves IV. Equivalent Single Layer to Double Surficial Layer," *Bull. Earthq. Res. Inst.*, **29** (1951), 519.

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

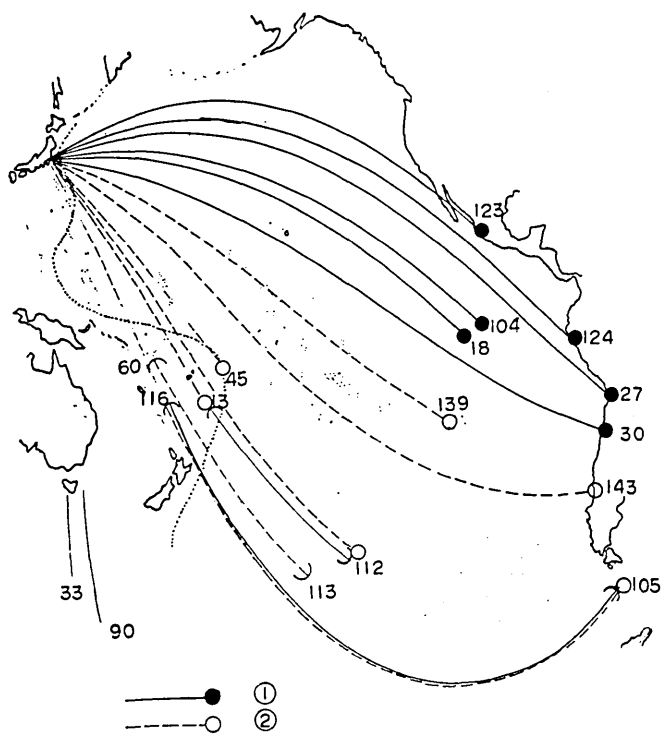
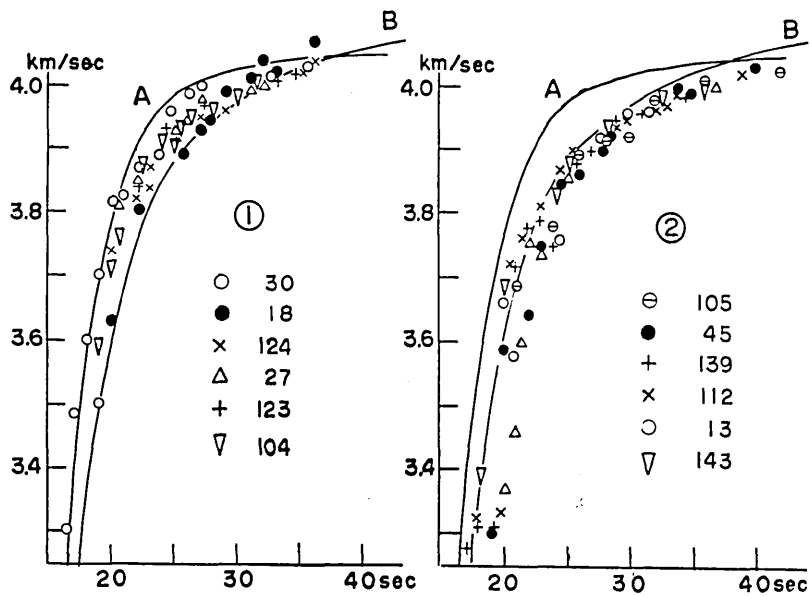


Fig. 7-a.

Fig. 7. Comparisons of the dispersion data with theoretical curves.

a) 1, 2~A, B b) 3, 4~B, C, D c) 5, 6, 7~D, E

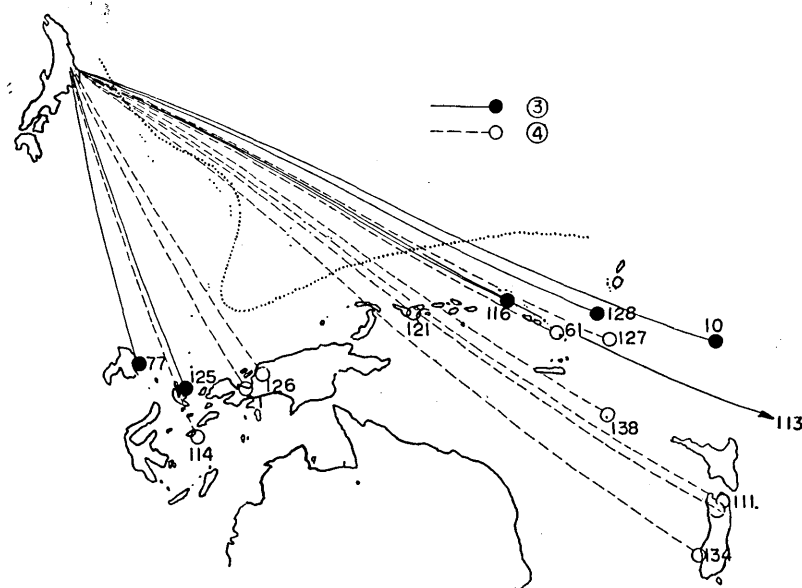
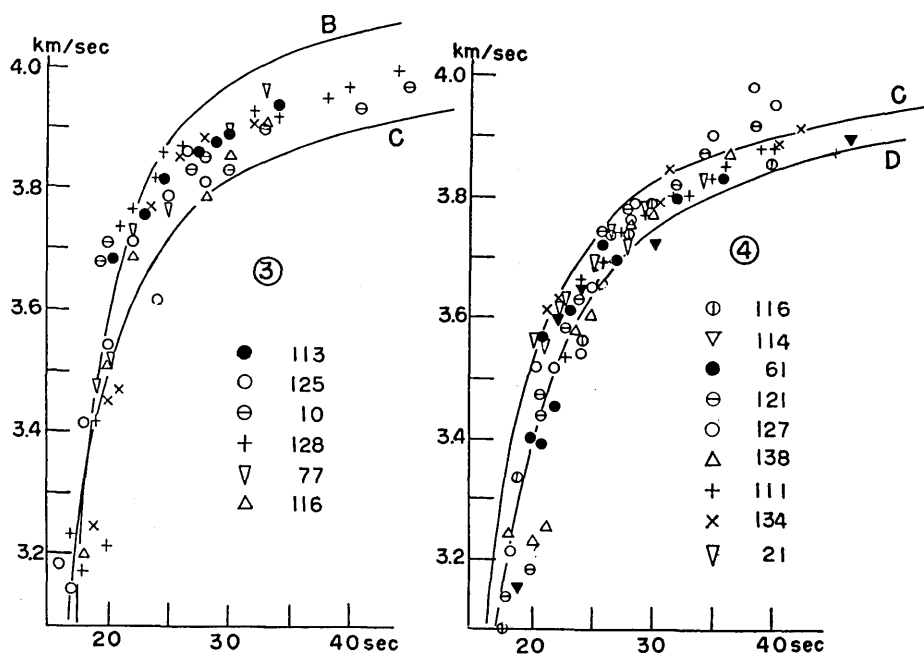


Fig. 7-b.

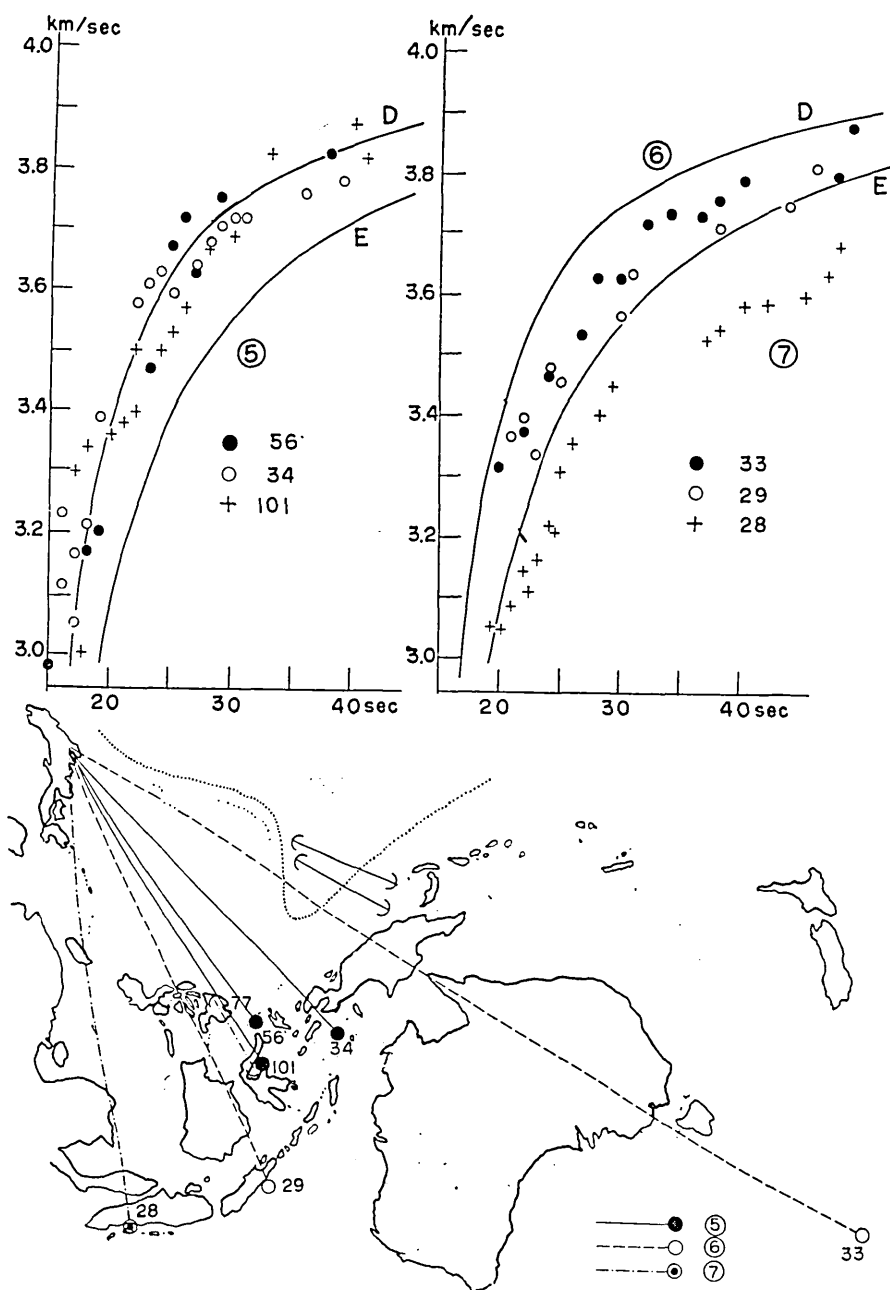


Fig. 7-c.

Because of this, the curves A, B, C, D and E will be used here only for the purpose of discovering the crustal property which corresponds to the seven kinds of dispersion data.

Comparing the observed dispersion data with theoretical curves from A to E in Fig. 7, it can be well recognized that the main factor which gradually changes the dispersion data from 1 to 7 is the velocity of the compressional waves in the crust. Of course, several trials were made to explain the shift in the observed curves by thickening the crust, but it was found that the best explanation of the observed departure from the purely oceanic dispersion is attained by decreasing the velocity in the crust. Referring to Hill's model for the oceanic crustal structure given before, the first solid layer of our model (crust) is considered to be composed of two layers, the uppermost of which is volcanic rock or consolidated sediments and the lower one, basaltic rock. Therefore, the decrease in the compressional wave velocity in the crust may be caused by the increase in the thickness of the lower velocity layer, the layer of volcanic rock, which covers the basaltic rock. This is the same conclusion we arrived at in section 2. Besides, much other observational evidence supports our suggestion. For instance, R. W. Raitt¹⁰⁾ obtained a smaller value of α in the consolidated layer in the Capricorn region (5.09 ± 0.52 km/sec) than in the Mid-Pacific region (5.38 ± 0.73 km/sec); He also found,¹¹⁾ through the extensive measurements of crustal structure in the surrounding sea of Bikini atoll, that the surface layer forming the ocean floor in these regions was characterized by a layer of thickness of nearly 2 km, with such a low compressional wave velocity as 3.0 km/sec. This result is also consistent with our own suggestion.

4. Some information on the crustal conditions in the continental side of the "Andesite line"

The crust of the earth beneath the Pacific Ocean south and south-east of Japan is much disturbed by active orogenic movements. The crustal structures along the path through such a region will show local variation. Therefore, the observed group velocities of Rayleigh waves along a certain path across such a region will be composed one. For

10) R. W. RAITT, "Seismic Refraction Studies of the Pacific Ocean Basin. Part I: Crustal Thickness of the Central Equatorial Pacific," *Bull. Geol. Soc. Amer.*, **67** (1956), 1623.

11) R. W. RAITT, "Seismic Refraction Studies of Bikini and Kawajalein Atolls," *Proc. Pap. U.S. Geol. Surv.*, **260** (1954), 507.

instance, when Rayleigh waves pass across two regions A and B with different crustal structures, the resultant group velocity V can be found by the following simple relation,

$$\frac{k\Delta}{V_A} + \frac{(1-k)\Delta}{V_B} = \frac{\Delta}{V}$$

in which, V_A and V_B are the group velocities of Rayleigh waves across A and B regions respectively and k is the ratio of the path length through the region A to the total one (Δ). Therefore, if we know two kinds of dispersion curves corresponding to these two regions, we can obtain the resultant group velocity V for each period as well as the resultant dispersion curves for various values of k . Some examples are shown in Fig. 8 by broken curves for $k=0.2, 0.4, 0.6$ and 0.8 . For

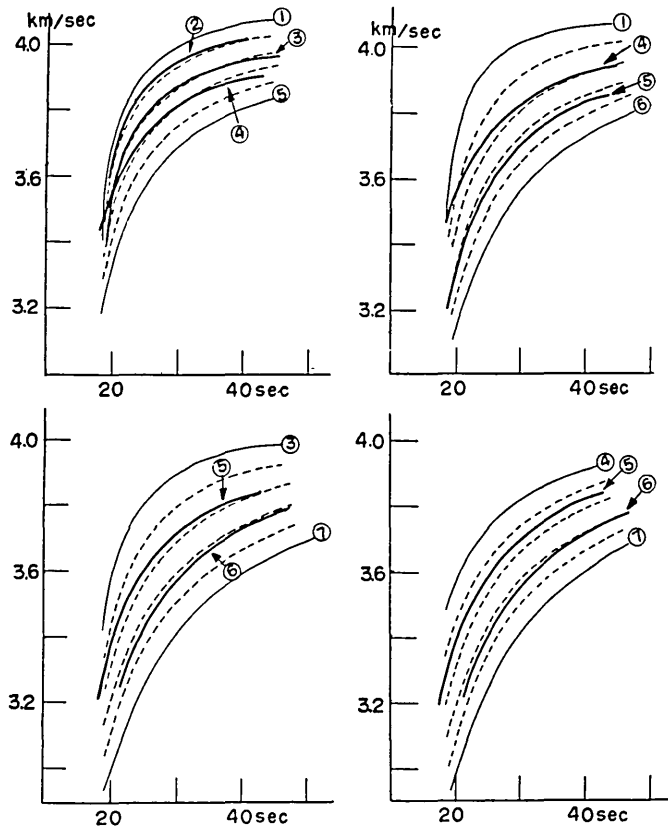


Fig. 8. Resultant dispersion curves (broken lines) calculated from two kinds of dispersion curves (the uppermost and lowermost ones).

instance in Fig. 8-a, the uppermost broken curve corresponds to the resultant one when Rayleigh waves travelled across the region "5" by 20% and the region "1" by 80%. (In order to prevent further trouble in terminology, we shall use, for instance, "the region "3"" instead of "the region across which Rayleigh waves show a dispersion characteristic of No. 3"). The thick solid curves mean other kinds of observed dispersion curves.

This results given in Fig. 8 support the previous consideration. For instance, in Fig. 8-a, curve 2 can be considered the resultant one when Rayleigh waves travelled through two different regions of crustal structure "1" and "5" with a path length ratio of 1:4. When this ratio becomes 2:3 or 3:2, the resultant curve will become "3" or "4" respectively.

This idea is schematically outlined in Fig. 9. In this figure, the region "1" and "7" represents the oceanic and continental crustal structure respectively, and the region "4" the intermediate one. Suppose now that the epicenters are distributed as shown in this figure, the resultant characteristic numbers of Rayleigh wave dispersions observed at a station (marked by a double circle) will become such as those shown beside each epicenter. When there is a good chance to obtain the dispersion data of a shock for which the travelling path occupies a part of the path of another shock, the dispersive characteristic number for the remaining part will also be

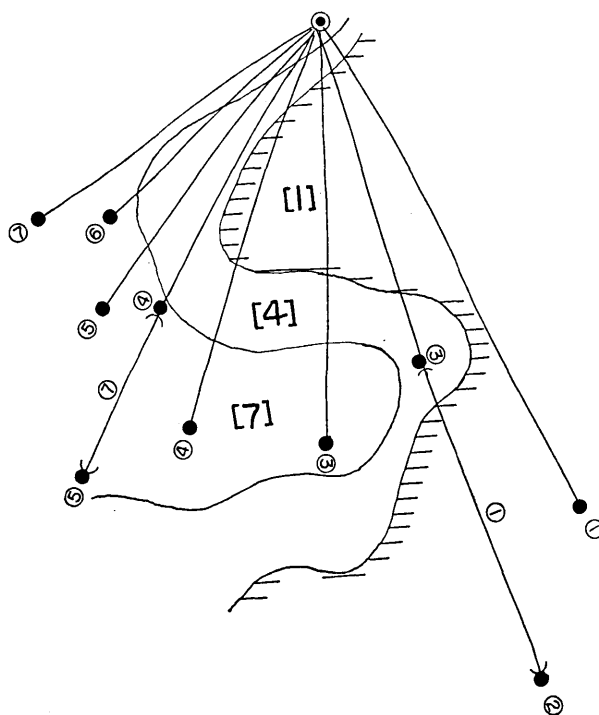


Fig. 9. Schematic figure which shows how the resultant dispersive character will become when the path runs through the different structured region with different ratio of path lengths.

calculated from the difference between the travel-times along these two paths. Such cases are also shown in brackets in this figure.

Our procedure is, however, entirely the reverse of the above. What we know are the locations of the epicenters and the characteristic numbers of the resultant dispersions. In some cases we may obtain the dispersion curves for a rather restricted region by subtracting the travel-times required along two suitable travelling paths. From these data we want to discover the boundary of such a region as "4" in

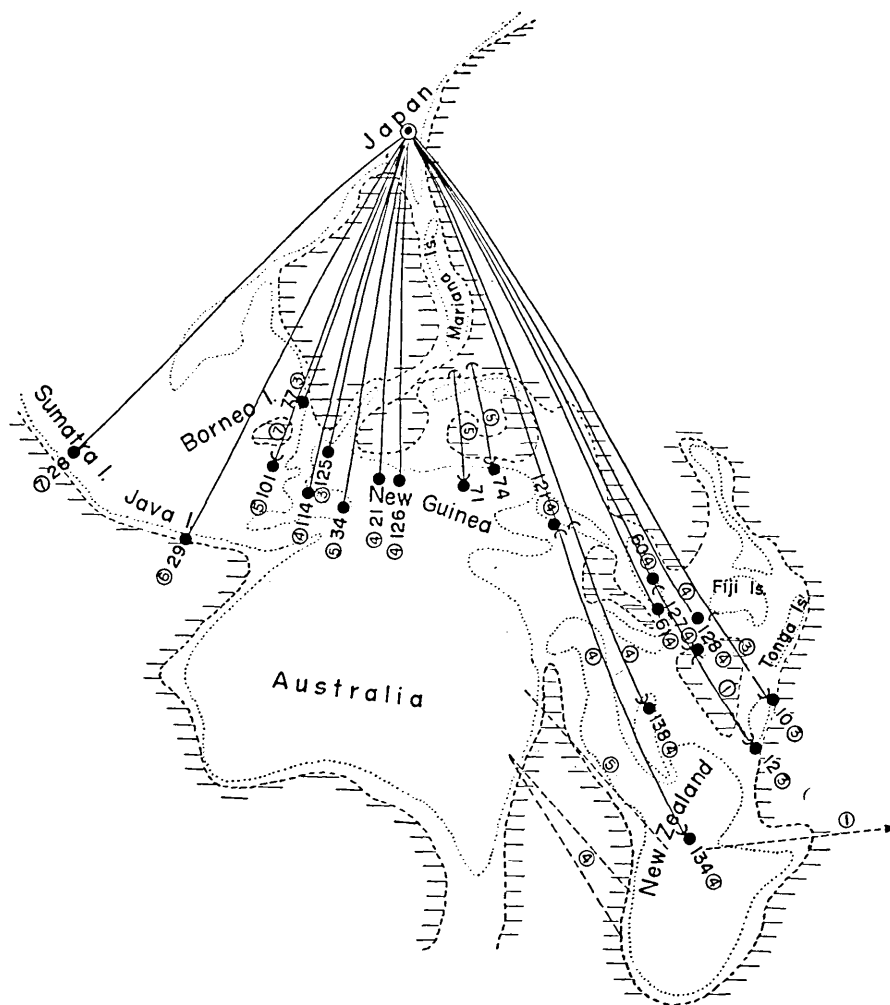


Fig. 10. The characteristic numbers of dispersions for the paths across the southwestern Pacific Ocean.

Fig. 9. Of course, help from geographical and geological data is needed.

Our data are summarized in Fig. 10, in which the hatched regions indicate those parts where the sea depth is greater than 4 km and the dotted curves show the 2 km sea depth line. In order to avoid complications in the figure, all the coastal lines are omitted. The paths for several cases when the local dispersive character along the paths could be found by subtracting the travel-times are also shown by lines with brackets together with their characteristic numbers.

C. B. Officer¹²⁾ studied the Rayleigh wave dispersion across the Tasman Basin. The data were re-plotted in our group velocity versus period diagram in which the ratio of velocity scale to period scale is ten times larger than the original ones. The results are shown in Fig. 11. Comparing these dispersion data with those given in Fig. 7, we can recognize that the dispersive character of Rayleigh waves for the central and northern Basin (white circles and cross marks respectively) may be expressed as "4" and "5" respectively according to our notation. These available data are also added in Fig. 10. The data summarized in this figure is, however, not sufficient for the performance of our plan. In order to obtain reliable results, the writer will postpone the conclusion of this work for a future time. Beside the data at Tsukuba Station, those at another Station for which the travelling paths intersect the present ones

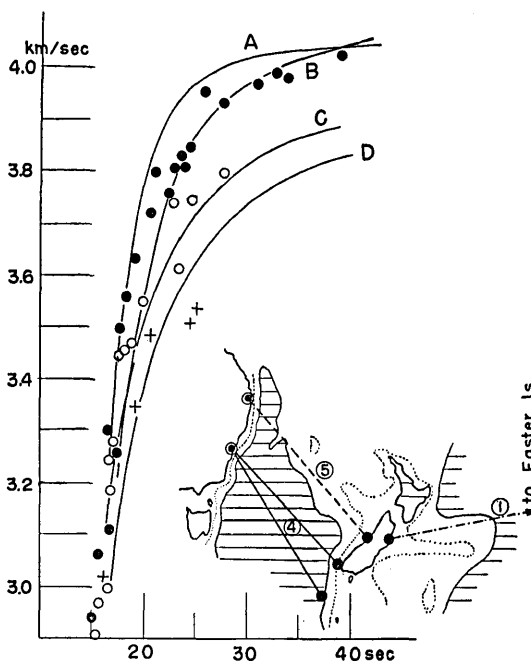


Fig. 11. Dispersion data of Rayleigh waves in Tasman Basin by C. B. Officer. Velocity scale to period one in the dispersion diagram is ten times exaggerated as the original. Theoretical dispersion curves A, B, C and D before used are shown for comparison. Hatched regions mean the sea with more than 4 km depth, and dotted curves are the 2 km depth contour line.

12) C. B. OFFICER, "Southwest Pacific Crustal Structure," *Trans. Amer. Geophys. Union*, **38** (1955), 449.

will be quite useful.

However, the following two suggestions may be given here from the present data.

(1) The dispersive characteristic numbers for the shocks (114), (34), (21) and (126), the paths of which crossed the Mariana Sea, are nearly the same as those for the shocks (60), (61), (127) and (128) near the Fiji Islands. Considering here that approximately 60% of the travelling paths of the latter group are occupied by the oceanic region, off east of the Mariana Trench, we may suggest that some part of the Mariana Sea has an oceanic crustal structure, though it lies on the western side of the "Andesite line". In other words, there may be a "hole" of oceanic structure even on the continental side of "Andesite line".

(2) The possibility of another small "hole" may be suggested around the region surrounded by the Tongas, Fijis, New Caledonia and New Zealand, because the characteristic number for the region between the two epicenters (127) and (12) was found to be "1" from the difference between the two travel-times.

5. Conclusions

The dispersive character of Rayleigh waves in some parts of the Pacific Ocean deviates from the purely oceanic through the existence of oceanic islands or atolls in the travelling path. Particularly, the character deviated remarkably in the western side or around the "Andesite line" in the south-western Pacific Ocean. The physical conditions at or around such "rashes" on the sea-bed which affect the dispersive character of Rayleigh wave were investigated.

At first, the relation between the dispersive characteristics and the average sea water depths was studied. Synoptically, these two were correlated. But, this correlation was disturbed in the region around the "Andesite line"; that is, the dispersive character largely varied in spite of the almost equal water depths along the paths. This anomaly seems to occur owing to the presence of the volcanic rock layer which may cover the basaltic layer with various thicknesses.

Secondly, several theoretical dispersion curves for different crustal models were compared with seven kinds of observed dispersion curves which was obtained in the previous two papers. From these comparisons, the same conclusion was derived. That is, the shift in the dis-

persive character from a purely oceanic to rather the continental, is caused by the decrease in the body wave velocity in the crust owing to the presence of a layer of volcanic rocks in the oceanic islands region. The higher temperature in the crust owing to the possible magma reservoirs may also play a part in decreasing the body wave velocity in the crust around these region.

A plan to estimate the local crustal structures for the complicated regions by the group velocity method was also outlined. As the data we have obtained were still insufficient to complete this plan, the completion of this work was postponed to a future time. However, the following proposal was made.

Two small oceanic regions exist the continental side of the "Ande-site line". One exists in the Mariana Sea and the other in the region surrounded by New Caledonia Island, the Fuji Islands and New Zealand.

6. Acknowledgments

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1. 日本周辺の海洋底をつたわるレーリー波の分散 (第三報)

—東南太平洋の地殻構造—

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太平洋の海底を伝わって日本にやってくるレーリー波の分散が7種に分類できることは、第1,第2報で詳しくのべてきた通りである。筆者は、これらのうち、従来から知られている純海洋的な分散と同一視される分散に対して番号1を、そして次第にそれが陸的なものに移るにつれて、それぞれ2,3,4...という番号をつけた。7は最も陸的なもので、スマトラ島の地震でえられたレーリー波の分散がこれに属する。

同じ海洋底を伝わるにかかわらず、なぜ径路によってこのように様々の分散傾向が現われるのか、これが残された重要な問題であつた。

M. N. Hill が、屈折法による多くの資料をまとめてつくつた海洋底の地殻構造に関する代表的なモデルを参考にし、今回観測されたレーリー波の波長も考慮して、水—固体—半無限固体という二重層構造を仮定し、いくつかの分散曲線を計算し、それらと今回の7種の分散曲線とを相互に比較した結果(第7図)、分散の傾向が、2,3,4...と徐々に純海洋的なものから外れてゆく原因は、むしろ地殻の厚さが厚くなつてゆくためも多少はあるけれども、それだけでは解決できず、むしろ、地殻内をつたわる実体波の平均速度がかなりおそくなつてゆくためだ、ということが分かつた。この速度減少は、それぞれの径路の地理的な条件を考え合せて見ると、Hill のモデルによる第二層、

つまり、火山の噴出物からなる層の厚みの増大によつて生じていると考えられる。つまり、太平洋上に点在するたくさんの海底火山の周辺では、場所によつていろいろの厚さで火山の噴出物が堆積していると思われるが、このことが、全体としての地殻内の実体波の速度に変化を生じ、従つて、そうした領域内を通るレーリー波の分散を変えている、と考えてよさそうである。あるいは、この速度の減少は、もし岩漿の溜りでもあったと、その熱によつて引起されているかも知れない。径路にそつての平均的な海の深さと、レーリー波の分散の傾向との関係も調べてみた(第3図)が、全体してみると、海が浅くなるにつれて、分散も陸的なものに移つてゆくようである。けれども、この大勢を著しく乱すいくつかの径路が発見された。こうした径路に関する限り、その平均的な海の深さも、更には深さの分布も殆んど同一であつても、分散の傾向だけは著しい相異を見せるのである(第5図)。この異常性もやはり、火山岩層の厚さの相異ということで説明することができた。

日本の南方および南東方海底は、地殻変動の最も活発な地域である。それでこのような複雑な変化の多い地殻内を伝わつてきたレーリー波の分散から、径路にそつての平均的な地殻構造をきめても余り意味がない。事実、観測された7種の分散のうちのいくつかは、それぞれ異なつた地殻構造を異なつた群速度で伝わつてきた結果生じたものと解釈できる(第8図)。筆者は、このような場合にも、これらの異なつた地殻構造をもつ領域自体の分散を推定し、従つてそれからそれぞれ構造を推定しうる一つの案を提出した。現段階では、未だ資料不足の感があるので、この方法を実際に適用するには至らなかつたが、この考え方に基つくと、今までの資料だけでも次のことはいえると思う。即ち、安山岩線の西側、つまり陸的構造と考えられている側にも、少なくとも2カ所、海的構造をしている「穴」が存在することである。1カ所は、マリアナ海の一部、もう1カ所はニューカレドニア島、フィジー諸島、それにニュージーランドで囲まれた海域である。
