

12. *Group Velocity Distributions of Rayleigh Waves and Two Upper Mantle Models in the Pacific Ocean.*

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Abstract

Group velocity distributions of Rayleigh waves, which are expressed in terms of spherical surface harmonics, are newly calculated for the periods 40, 70 and 90 seconds. Lateral heterogeneity of the upper mantle under the ocean is represented by means of contour lines on the maps of group velocity distributions. Two upper mantle models for the youngest and oldest regions are proposed.

It is found from the regional group velocity characteristics that the famous oceanic model 8099 corresponds to the region of approximately 85 million year old ocean-floor east of the Hawaiian Islands. Group velocity is lowest in the youngest region with an age of 0 m.y. and highest in the oldest region of about 150 m.y. The group velocity difference between these two regions amounts as much as 0.5 km/sec (about 13%) at a period of 40~50 seconds.

The increase of surface wave velocity with age seems to be attributable to the thickening oceanic lithosphere and partly to the increasing shear wave velocities with age in the lithosphere or in the low velocity zone. The shear velocity in the low velocity zone for the youngest region is estimated to be 4.136 km/sec, and that in the oceanic lithosphere for the oldest region to be 4.728 km/sec. The thickness of the oldest lithosphere is estimated to be 85 ± 5 km.

1. Introduction

The propagation of surface waves across the Pacific and also the inversion problem have been studied by many seismologists, and the velocity of Rayleigh and Love waves travelling across this ocean has been made clear (e.g., SANTO, 1963; SANTO and SATÔ, 1966). Upper mantle models, systematically changing from ocean to continent, have been proposed by SAITO and TAKEUCHI (1966) making use of the dispersion data of periods shorter than 40 seconds.

In the previous work (YOSHIDA, 1977a; hereafter Paper I) a group velocity distribution of Rayleigh waves in the Pacific was determined for a period 50 seconds, employing the method of SATÔ and SANTO (1969),

in which the velocity at any location was expressed in terms of spherical surface harmonics. A high correlation between the group velocity and the ocean-floor age was found, namely the velocity increases with the lithospheric age, as pointed out by KAUSEL, LEEDS and KNOPOFF (1974), FORSYTH (1975a, b) and YOSHII (1975).

The present paper aims to develop the knowledge of Rayleigh wave velocity and solve the inversion problem, specially in relation to the ocean-floor age. For determining the regional dispersion characteristics of Rayleigh waves at periods longer than those studied by Santo and making clear the lateral heterogeneity under the Pacific, the group velocity distributions are newly calculated, and on the basis of this result two upper mantle models are constructed. One corresponds to the youngest region and the other to the oldest region in the Pacific. These models are compared with those proposed by SCHLUE and KNOPOFF (1977) which were constructed on the basis of phase velocity data.

2. Data and method

The dispersion data observed by ABE (1972), YOSHII (1975) and YOSHIDA and SATÔ (1976) are used. Group velocity data in the Philippine sea, not included in Paper I, are involved in the present analysis (Fig. 1), and so the velocity distribution in the west Pacific is more widely determined than that for the period 50 seconds. The velocity distribution is expressed as

$$\frac{1}{v(\theta, \varphi)} = \sum_{n=0}^{\infty} \sum_{m=0}^n A_n^m \cdot P_n^m(\cos \theta) \cdot \cos m\varphi + \sum_{n=1}^{\infty} \sum_{m=1}^n B_n^m \cdot P_n^m(\cos \theta) \cdot \sin m\varphi, \quad (1)$$

where the coefficients A_n^m and B_n^m of spherical surface harmonics are determined from the following set of equations by means of the method of least squares

$$t_i = \int \frac{dA_i}{v(\theta, \varphi)}. \quad (2)$$

In this equation t_i is the observed travel time of Rayleigh waves and dA_i is the line element of the path i , and $1/v(\theta, \varphi)$ is synthesized using the coefficients thus obtained. This is exactly the method first proposed by Satô and Santo, and employed in Paper I.

It is known that Rayleigh waves propagating across oceanic basins have a maximum group velocity around the period 40 seconds (KUO, BRUNE and MAJOR, 1962), and the Rayleigh wave dispersion near that period is very sensitive to the physical properties of the oceanic litho-

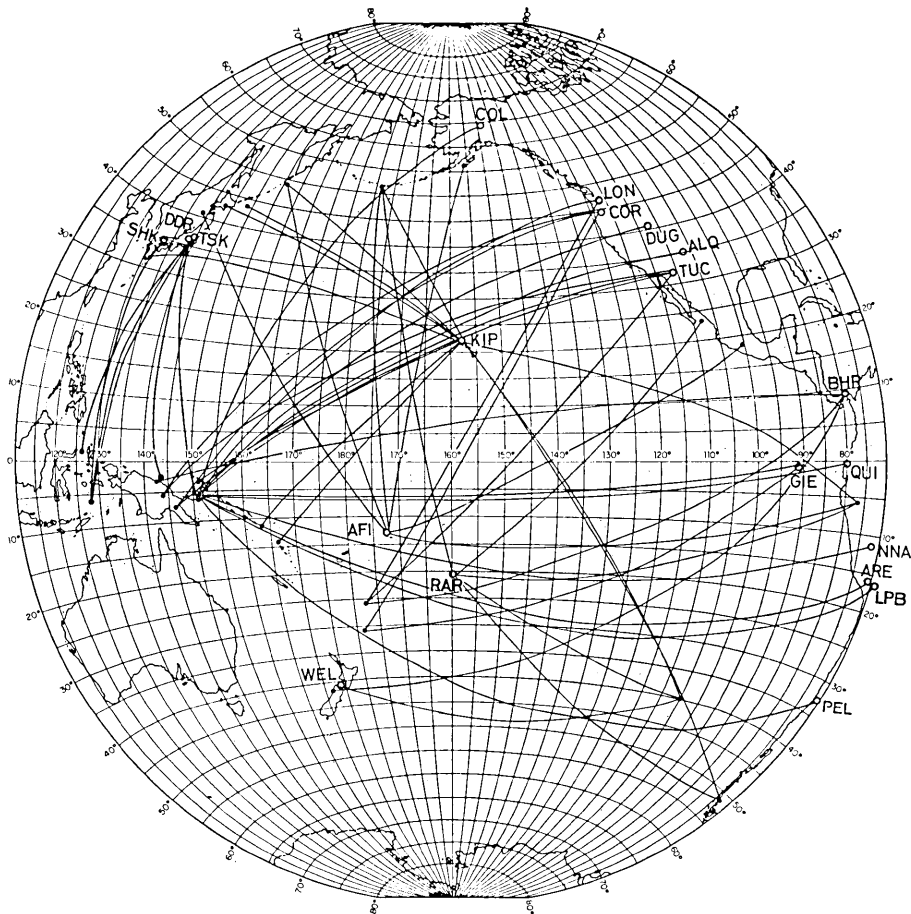


Fig. 1. Great circle paths between epicenters (solid circles) and observation stations (open circles). Note that the paths also cover the Philippine Sea.

sphere. Hence the velocity distribution for the period 40 seconds was calculated. The distributions for longer periods, 70 and 90 seconds, were also calculated for making clear the lateral heterogeneity of the deeper part of the lithosphere and asthenosphere.

The data are listed in Table 1, and the coefficients A_n^m and B_n^m (Table 2) in the expression (1) are determined on the basis of the above observations through the equation (2). All the data used satisfy the following criterion of the travel time residuals, as adopted in Paper I,

$$\frac{|TO - TC|}{TO} < 1\% \quad (3)$$

where

Table 1. List of epicenters, stations, and observed group velocities of Rayleigh waves for periods 40, 70 and 90 seconds.

No.	Station Abbreviation	Epicenter		Station		Distance km	Group Velocity		
		Latitude	Longitude	Latitude	Longitude		(T=40 km/sec)	70	90 sec)
1	TUC	- 5.07	144.20	32.310	-110.782	11726.	4.005	3.886	3.814
2	BHP	-41.72	172.03	8.961	- 79.558	12188.	3.876	3.798	3.743
3	KIP	- 5.55	- 77.20	21.423	-158.015	9282.	3.917	3.836	3.789
4	AFI	- 5.55	- 77.20	-13.909	-171.777	10350.	3.917	3.836	3.789
5	RAR	- 5.55	- 77.20	-21.217	-159.773	9016.	3.890	3.813	3.771
6	GIE	-30.97	-178.13	- 0.733	- 90.300	9756.	3.913	3.777	3.713
7	BHP	- 3.38	143.29	8.961	- 79.558	15237.	4.000	3.900	3.825
8	KIP	- 3.56	150.90	21.423	-158.015	6205.	4.063	3.974	3.898
9	KIP	49.41	155.54	21.423	-158.015	5116.	4.035	3.938	3.856
10	AFI	49.41	155.54	-13.909	-171.770	7707.	4.070	3.975	3.899
11	KIP	43.92	148.63	21.423	-158.015	5474.	4.070	3.975	3.899
12	KIP	51.27	-179.17	21.423	-158.015	3787.	4.003	3.903	3.833
13	AFI	51.27	-179.17	-13.909	-171.777	7250.	4.066	3.972	3.893
14	RAR	51.27	-179.17	-21.217	-159.773	8244.	4.066	3.972	3.893
15	RAR	23.19	-107.99	-21.217	-159.773	7451.	4.025	3.883	3.785
16	KIP	42.48	143.04	21.423	-158.015	5907.	4.045	3.932	3.845
17	BHP	-25.85	-177.29	8.961	- 79.558	11202.	3.940	3.812	
18	TUC	-25.85	-177.29	32.310	-110.782	9535.	4.005	3.890	3.812
19	LON	-25.85	-177.29	46.750	-121.810	9773.	4.005	3.890	3.812
20	KIP	-51.94	- 74.14	21.423	-158.015	11441.	3.961	3.832	3.760
21	RAR	-51.94	- 74.14	-21.217	-159.773	7886.	3.985	3.874	3.801
22	KIP	32.26	131.78	21.423	-158.015	6959.	4.045	3.944	3.870
23	KIP	-14.13	166.56	21.423	-158.015	5510.	4.033	3.914	3.835
24	KIP	-11.03	163.41	21.423	-158.015	5530.	4.057	3.953	3.863
25	KIP	-39.80	-104.80	21.423	-158.015	8733.	3.945	3.821	3.763
26	RAR	-39.80	-104.80	-21.217	-159.773	5565.	3.990	3.869	3.793
27	WEL	-39.80	-104.80	-41.287	174.767	6554.	3.965	3.856	3.788
28	TUC	- 7.60	146.20	32.310	-110.782	11685.		3.920	3.820
29	COR	- 7.60	146.20	44.586	-123.303	10638.	3.990	3.920	3.820
30	COR	-30.04	-177.65	44.586	-123.303	9933.	3.990	3.900	
31	AFI	55.72	-155.95	-13.909	-171.777	7857.	4.030	3.890	
32	TUC	- 5.07	144.20	32.310	-110.782	11726.	3.970	3.890	
33	COR	- 5.07	144.20	44.586	-123.303	10602.	3.980	3.930	3.850
34	AFI	40.39	139.05	-13.909	-171.777	7866.	4.000	3.970	
35	AFI	18.31	-100.50	-13.909	-171.777	8594.	4.030	3.900	
36	ARE	- 5.40	151.50	-16.462	- 71.491	14716.	3.840	3.765	
37	LPB	- 5.40	151.50	-16.533	- 68.098	15041.	3.800	3.780	3.756
38	PEL	- 5.40	151.50	-33.144	- 70.685	13857.	3.925	3.760	3.735
39	GIE	- 5.40	151.50	- 0.733	- 90.300	13134.	4.000	3.947	
40	TSK	- 7.45	127.88	36.211	140.110	4995.	3.760	3.760	
41	LON	- 5.40	151.50	46.750	-121.810	10192.	3.982		
42	DUG	- 5.40	151.50	40.195	-112.813	10880.	3.961		
43	TUC	- 5.40	151.50	32.310	-110.782	11058.	3.987		
44	ALQ	- 5.40	151.50	34.942	-106.658	11453.	3.960		
45	NNA	- 5.40	151.50	-11.988	- 76.842	14347.	3.918		3.739
46	DDR	- 7.45	127.88	35.998	139.193	4948.	3.740		3.740
47	SHK	- 7.45	127.88	34.530	132.678	4669.		3.780	
48	DDR	- 5.87	151.10	35.998	139.193	4794.		3.800	3.780
49	DDR	- 1.42	126.22	35.998	139.193	4052.		3.790	
50	DDR	- 3.33	143.25	35.998	139.193	4367.		3.730	
51	DDR	- 8.77	120.39	35.998	139.193	5328.			3.750

Table 2. Coefficients of the expansion of $1/v(\theta, \varphi)$ into spherical surface harmonics for periods 40, 70 and 90 seconds. A_n^m and B_n^m are the coefficients of $P_n^m(\cos \theta) \cdot \cos m\varphi$ and $P_n^m(\cos \theta) \cdot \sin m\varphi$.

n	m	A_n^m (T=40 sec)	B_n^m	A_n^m (T=70 sec)	B_n^m	A_n^m (T=90 sec)	B_n^m
0	0	-0.2428		-0.2456		0.1941	
1	0	-0.6864		-0.0588		0.0608	
	1	-0.7433	-1.0386	-0.8235	-0.9378	-0.1439	0.0069
2	0	0.3137		0.4831		0.0518	
	1	-0.4843	-0.3028	-0.0875	-0.0507	0.0253	0.0449
	2	0.0365	-0.4032	-0.0114	-0.3458	-0.0277	0.0060
3	0	0.3208		0.1292		0.0019	
	1	0.0096	0.1031	0.1042	0.0684	0.0066	-0.0012
	2	-0.0322	-0.0616	-0.0125	-0.0164	-0.0011	0.0068
	3	0.0274	-0.0379	0.0189	-0.0308	-0.0013	0.0012
4	0	-0.0059		-0.0547			
	1	0.0237	0.0124	0.0196	0.0063		
	2	-0.0045	0.0064	0.0033	0.0043		
	3	0.0001	-0.0029	-0.0002	-0.0012		
	4	0.0016	-0.0010	0.0011	-0.0007		

TO=observed travel time

TC=calculated travel time through (1) and (2) employing the coefficients in Table 2

As seen in Table 2, coefficients A_n^m and B_n^m of the order up to 4 are obtained and used for the synthesis for the periods 40 and 70 seconds, while those up to 3 are available for 90 seconds because of a smaller amount of data. This treatment will be allowed since longer period waves are less affected by the small surface structures. The group velocity distributions newly obtained for the periods 40, 70 and 90 seconds are shown in Fig. 2 together with the one for 50 seconds.

3. Group velocity distributions

The calculated velocity distribution for the period 40 seconds is extremely close to that for 50 seconds (Figs. 2a and 2c): namely, the velocities in the Northwest and Mid-Pacific Basins are high (4.0~4.2 km/sec) and are low near the East Pacific Rise (3.6~3.8 km/sec). This pattern is not different for longer periods (Figs. 2c and 2d), and the general pattern of the distribution found in Paper I holds throughout the period range 40 to 90 seconds though the velocity decreases gradually with the period.

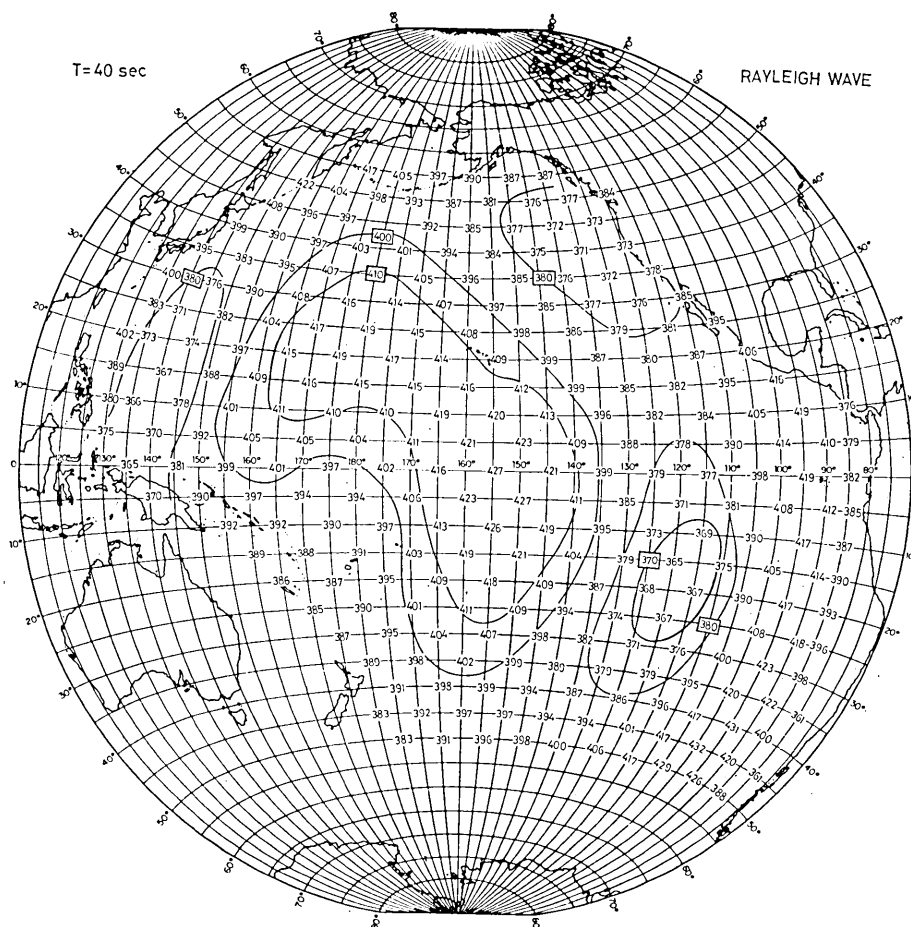


Fig. 2a.

Fig. 2 a—d. Group velocity distributions of Rayleigh waves in the Pacific as synthesized in terms of a series of spherical surface harmonics for periods 40, 50, 70 and 90 seconds. Unit: 10 m/sec. The velocity distribution for the period 50 seconds is taken from Paper I.

Four velocity maps (Fig. 2) show that the group velocity maximum occurs near the period 50 seconds in the West Pacific, while it occurs at 25 seconds near the East Pacific Rise (SANTO, 1963). Hence the period of the Airy-phase will be in the range from 25 to 50 seconds in the Pacific. The velocity distributions calculated above are consistent with the result of the Airy-phase analysis by SAVAGE (1969) and SAVAGE and WHITE (1969).

The velocities in the Philippine Sea are somewhat low compared with other west Pacific area, and rather close to those in the west coast of

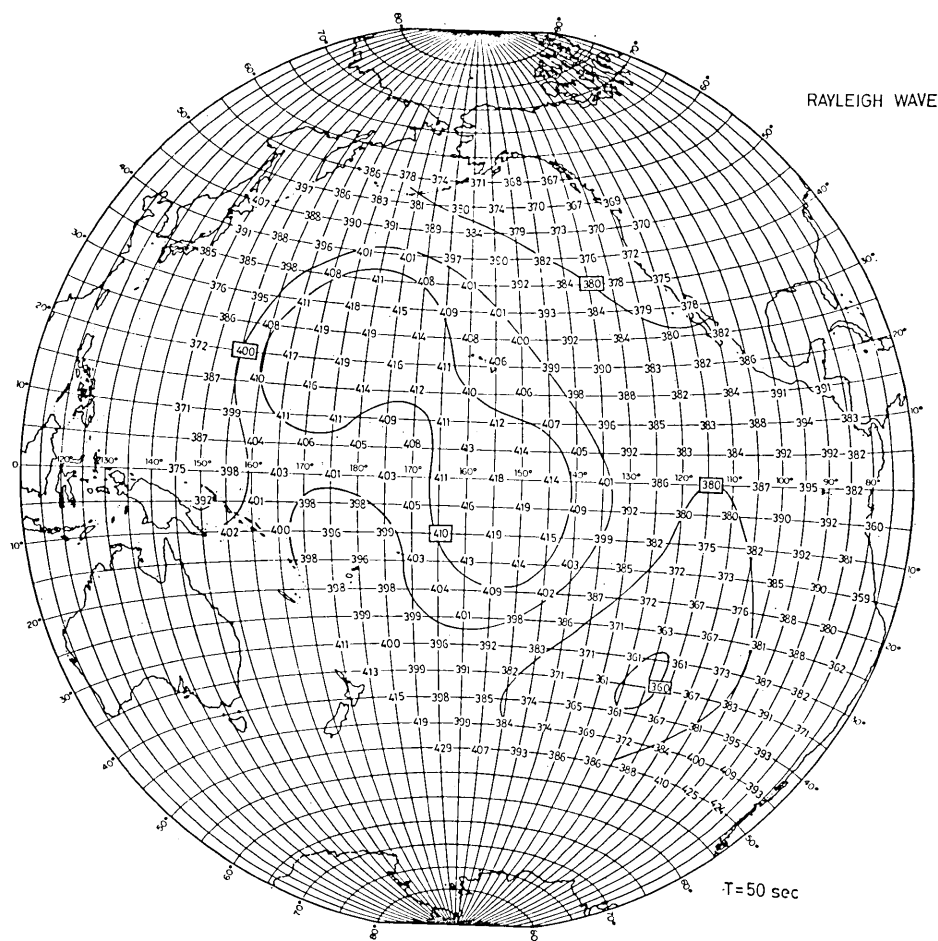


Fig. 2b.

North America belonging to the young region (Figs. 2a, 2c and 2d). This fact is in harmony with the fact that the Philippine Sea is a young and active region.

4. A schematic pattern of group velocity distributions

In Paper I a schematic map showing the velocity distributions was drawn based on the analysis for a period 50 seconds. The result obtained in the present analysis was superposed on that map and isochrons of the ocean-floor age inferred from geomagnetic lineations (ATWATER and MENARD, 1970; LARSON and CHASE, 1972) are also shown in the figure (Fig. 3). The arrows show common directions approximately perpendicular to the velocity

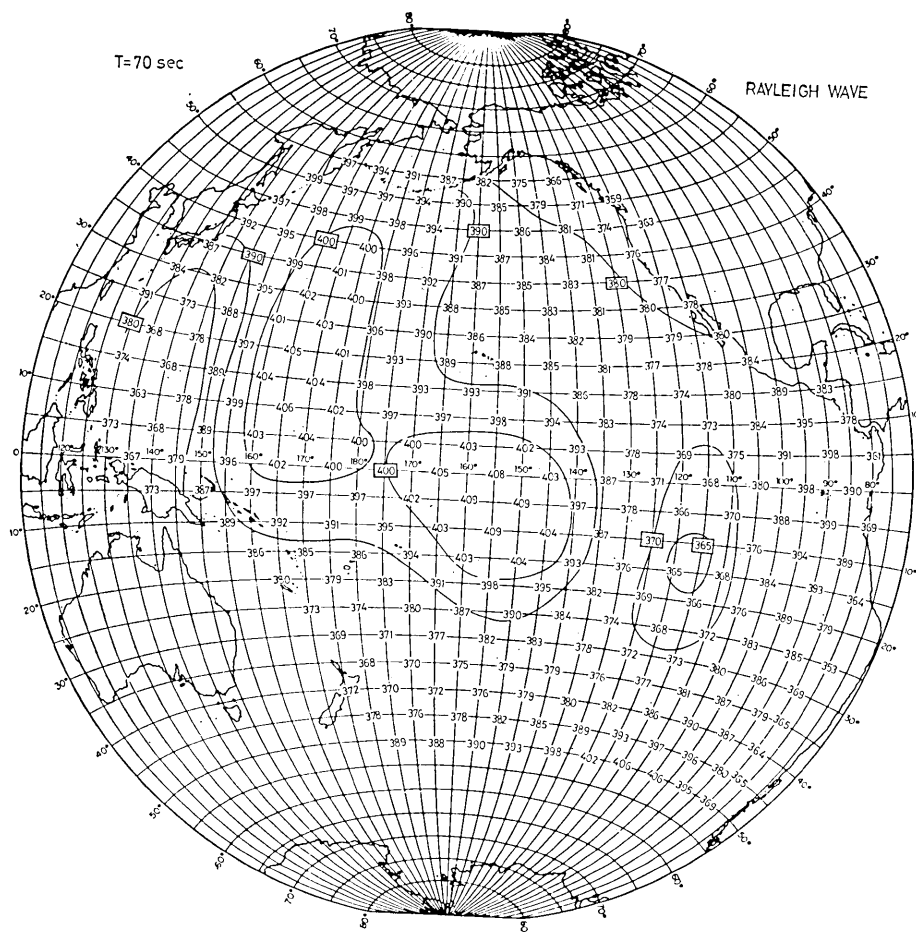


Fig. 2c.

contour lines in the group velocity map (Fig. 2). These arrows are also perpendicular to isochrons of the ocean-floor age. They may suggest the direction towards which the oceanic lithosphere grows. For the typical regions (A) (Lowest-velocity-area) and (C) (Highest-velocity-area) upper mantle models PC-MIN and PC-MAX were constructed. They are discussed in later sections.

5. Local group velocity and ocean-floor age

In Fig. 3 we can see that the ocean-floor age of the regions (A) and (C) is 0 and more than 150 m.y. respectively, and the Hawaiian Islands are located at a region with an age of about 90 m.y. The local group

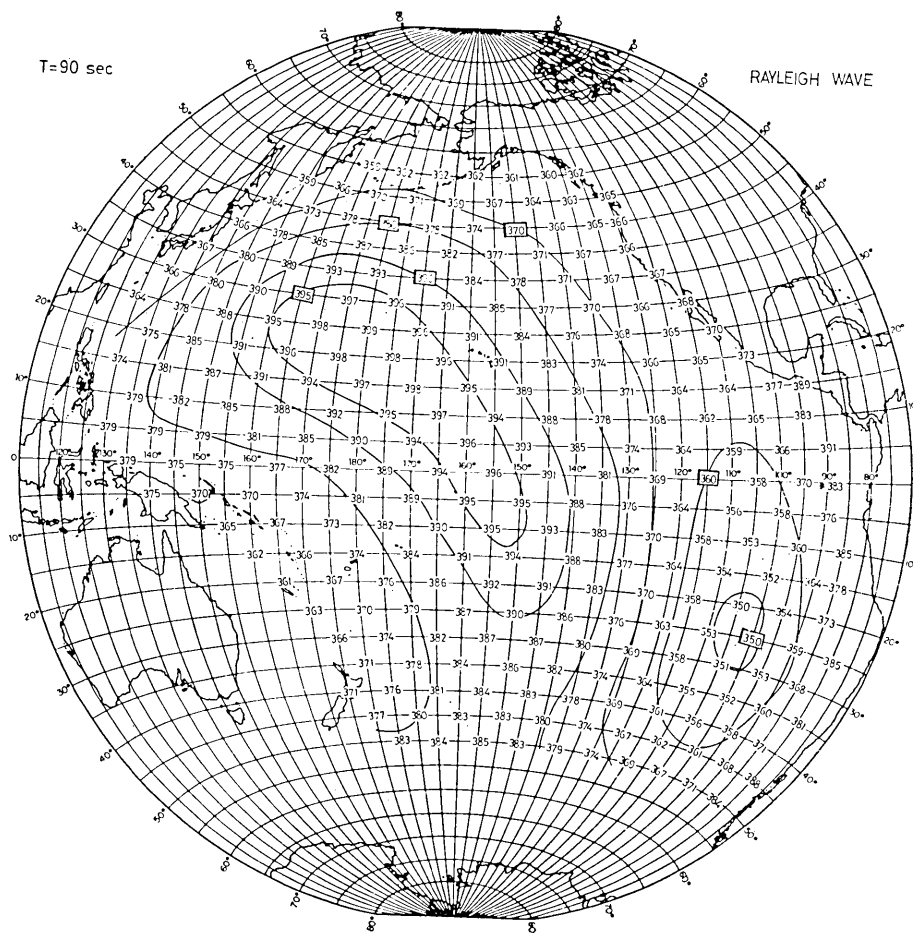
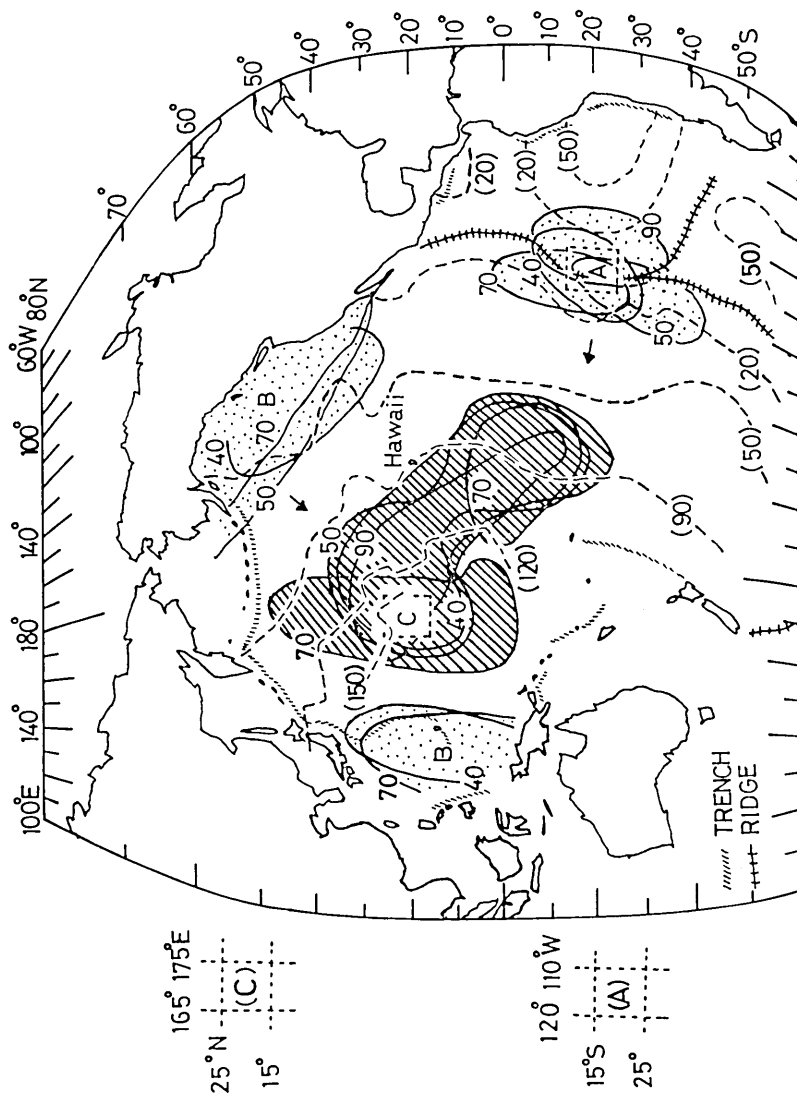


Fig. 2d.

velocities for the regions (A) and (C) and the Hawaiian region were determined from Fig. 2 and are shown in Fig. 4. In this figure the group velocities for the standard oceanic model 8099 (DORMAN, EWING and OLIVER, 1960) and for the regions of the age 0~20, 20~50, 50~90 and 90 m.y., observed by YOSHII (1975), are also shown.

We see in Fig. 4 that the upper limit of group velocity for the region (A) is nearly equal to the average velocity for the region of the age 0~20 m.y. and this fact seems reasonable taking into account the velocity and age relation. We also see that group velocities for the Hawaiian region is slightly higher than those for the model 8099 and that the velocity difference between the region (C) and the age of more than 90 m.y. is large at short periods.



A: Lowest-velocity-area, B: Low-velocity-area, C: Highest-velocity-area

Fig. 3. Schematic map of the group velocity and the ocean-floor age in the Pacific. In the region A the velocity is the lowest and is the highest in the region C. The velocity in the region B is comparatively low. Dashed curves indicate isochrons 20, 50, 90, 120 and 150 m.y. of the ocean-floor age with the numerals parenthesized. The boundaries of the regions A, B and C are drawn on the basis of the velocity distributions (Fig. 2) which were determined for each period indicated near the boundaries. The arrows show the direction of velocity increase perpendicular to the contour lines given in Fig. 2d. The square areas (A) and (C) of about 1000 km X 1000 km defined in the left side space are typical areas in the regions A and C. They are also shown in the map by enclosures.

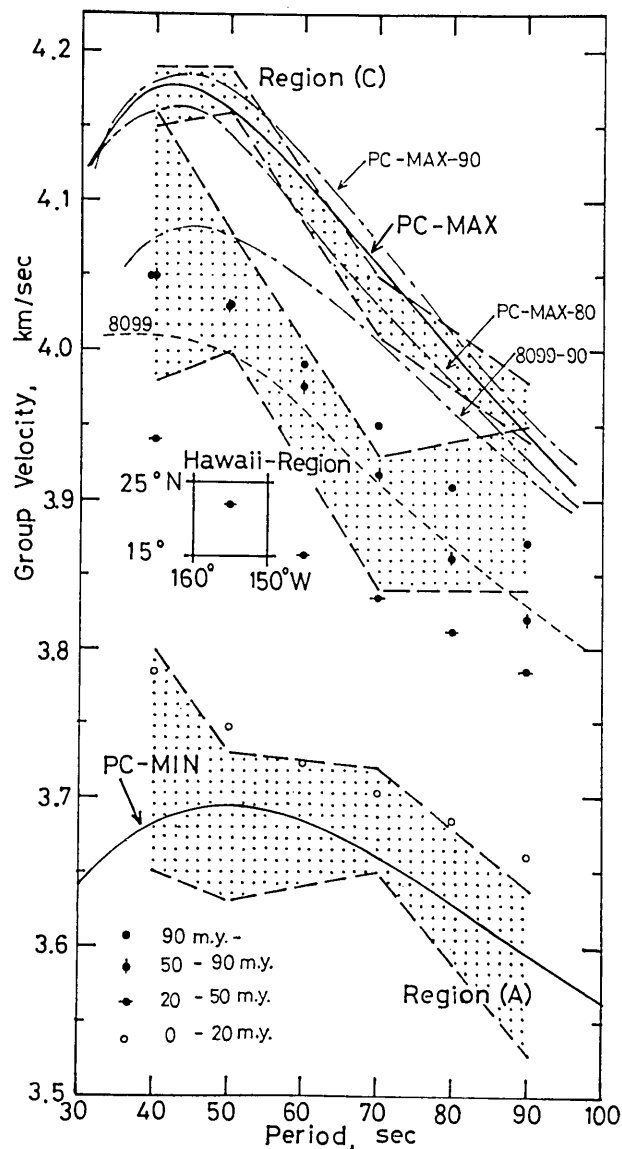


Fig. 4. Local group velocities for the regions (A) and (C), and the region near the Hawaiian Is. Upper and lower limits of velocities for periods 40, 50, 70 and 90 seconds, as taken from Fig. 2, are connected by dashed lines and the intermediate part is marked with dots. Solid lines are theoretical dispersion curves calculated for the models PC-MIN or PC-MAX. The lithospheric thickness of the models PC-MAX-90 is 90 and 8099-90 is 90 km and that of the model PC-MAX-80 is 80 km. All the other parameters are the same.

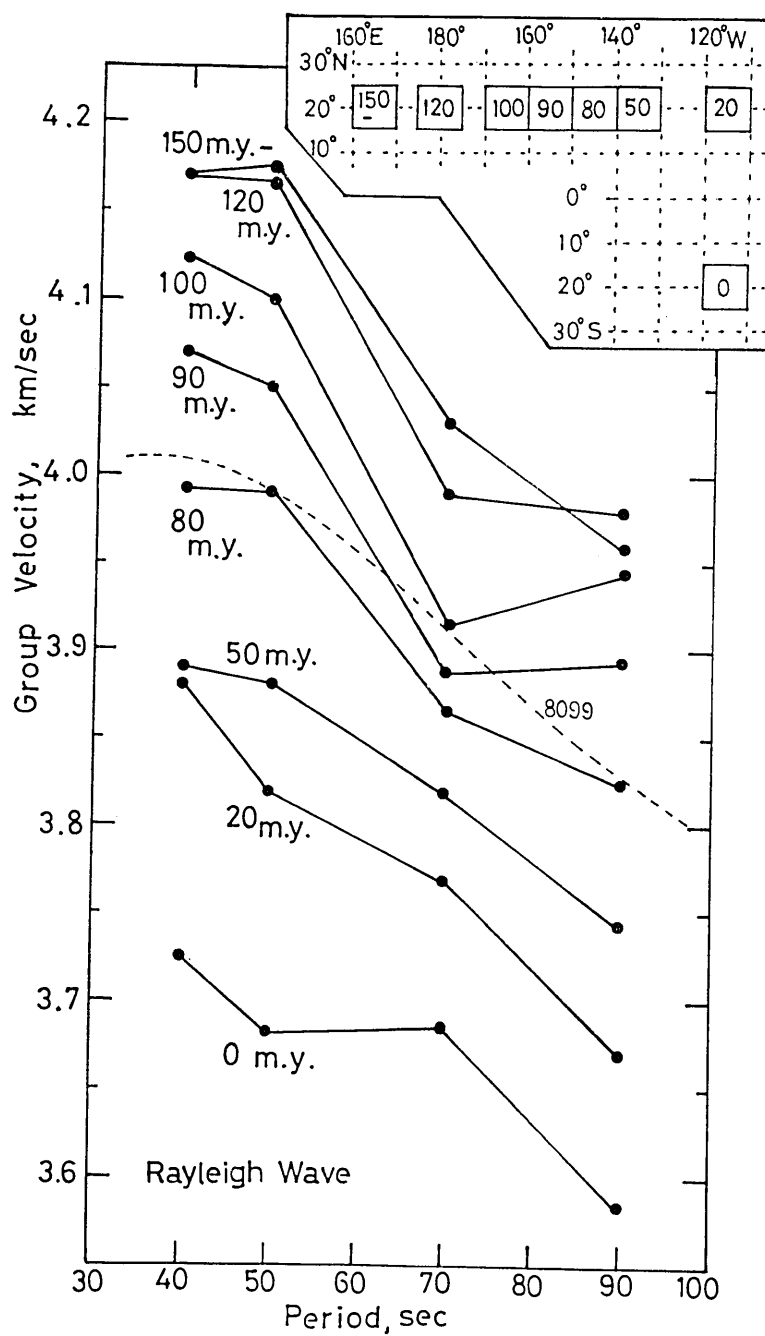


Fig. 5. Local group velocity characteristics associated with the ocean-floor age. Numerals in the enclosed areas, in the upper right, are the age in million years.

In Fig. 5, associated with the ocean-floor-age, the local group velocities are shown for a number of areas, which are indicated in the upper right. These areas are chosen with reference to the geomagnetic lineations studied by Atwater and Menard, and Larson and Chase, and local velocities are taken from the distributions in Fig. 2. It is obvious from Fig. 5 that the group velocity increases with the age. We can also understand that the famous model 8099 corresponds to the region of the age of about 85 m.y. (see also Fig. 4).

6. Models PC-MIN and PC-MAX

In the Pacific, continuously varying underground structures from ocean to continent were first constructed by SAITO and TAKEUCHI (1966) by making use of Santo's group velocity data.

As stated above, the models PC-MIN and PC-MAX were constructed for the lowest velocity region (A) and the highest velocity region (C) respectively, on the basis of the regional dispersion characteristics of Rayleigh waves referring to many oceanic models proposed by Dorman et al., Saito and Takeuchi, and Yoshii. In the generation of these two models, care was mainly taken in the shear velocities of the oceanic lithosphere (the lid) and the low velocity zone (the LVZ) and the thickness of the lid, since surface wave dispersion is very sensitive to those parameters for the periods studied here. Layer parameters for two models are shown in Table 3 and Fig. 6, and their essentials are summarized as follows.

- 1) The lid is not found in PC-MIN.
- 2) The LVZ in PC-MIN extends from the depth 9.6 to 220 km, where the shear velocity is 4.136 km/sec, 2% reduction of that for the region of the age 0~20 m.y. in Yoshii's model.
- 3) The depth of the lid in PC-MAX extends to 85 km, which is 25 km thicker than that in the model 8099 and a set of models by Saito and Takeuchi. The shear velocity there is 4.728 km/sec, 2.5% higher than the model 8099, and is close to the value 4.7 km/sec in a most oceanic model by Saito and Takeuchi.
- 4) The shear velocity of 3.811 km/sec at the third layer in PC-MAX is 3% higher than that in the model 8099.
- 5) In PC-MAX, the shear velocity in the LVZ is 4.30 km/sec, equal to that in the the model 8099.

The shear velocity distribution (Fig. 6) of the models PC-MAX (more than 150 m.y.), 8099 (85 m.y.) and PC-MIN (0 m.y.) suggests that the oceanic lithosphere thickens with age, and the velocities in the lithosphere and low velocity zone increases with age. Referring to a set of group velocity curves for the region (C) (Fig. 4) we can estimate the upper limit

of the thickness of the oceanic lithosphere in the Pacific. It is inferred that even the oldest part can hardly have a thickness of 90 km.

7. Upper mantle models and phase velocity dispersion

Recently, numerous phase velocity data of surface waves across the Pacific are reported, which were determined by means of the single-station

Table 3. Structure constants for the models PC-MIN and PC-MAX.
For layer parameters below the depth 220 km those of the model 8099 are used.

MODEL PC-MIN

Layer Number	Thickness km	Density g/cc	P-wave Velocity km/sec	S-wave Velocity km/sec
1	3.6	1.03	1.52	0.00
2	1	2.10	2.10	1.00
3	5	2.84	6.41	3.70
4	210.4	3.30	7.70	4.1356
5	100	3.5265	8.49	4.60
6	90	3.6040	8.81	4.80
7	90	3.7650	9.32	5.1925
8	100	4.0100	9.97	5.4925
9	100	4.23	10.48	5.79
10	100	4.41	10.85	6.03
11	100	4.5450	11.12	6.20
12	100	4.64	11.33	6.3150

MODEL PC-MAX

Layer Number	Thickness km	Density g/cc	P-wave Velocity km/sec	S-wave Velocity km/sec
1	5	1.03	1.52	0.00
2	1	2.10	2.10	1.00
3	5	2.84	6.41	3.811
4	74	3.34	7.82	4.7278
5	135	3.4425	8.17	4.30
6	100	3.5265	8.49	4.60
7	90	3.6040	8.81	4.80
8	90	3.7650	9.32	5.1925
9	100	4.01	9.97	5.4925
10	100	4.23	10.48	5.79
11	100	4.41	10.85	6.03
12	100	4.5450	11.12	6.20
13	100	4.64	11.33	6.3150

method (KAUSEL, LEEDS and KNOPOFF, 1974; LEEDS, 1975; FORSYTH, 1975a and b; YOSHIDA, 1977b). It will be useful to compare the phase velocities calculated for the models PC-MAX and PC-MIN with the observed ones. We see in Fig. 7 that the phase velocity for these models successfully gives the upper and lower limits of one of the Rayleigh waves in the Pacific.

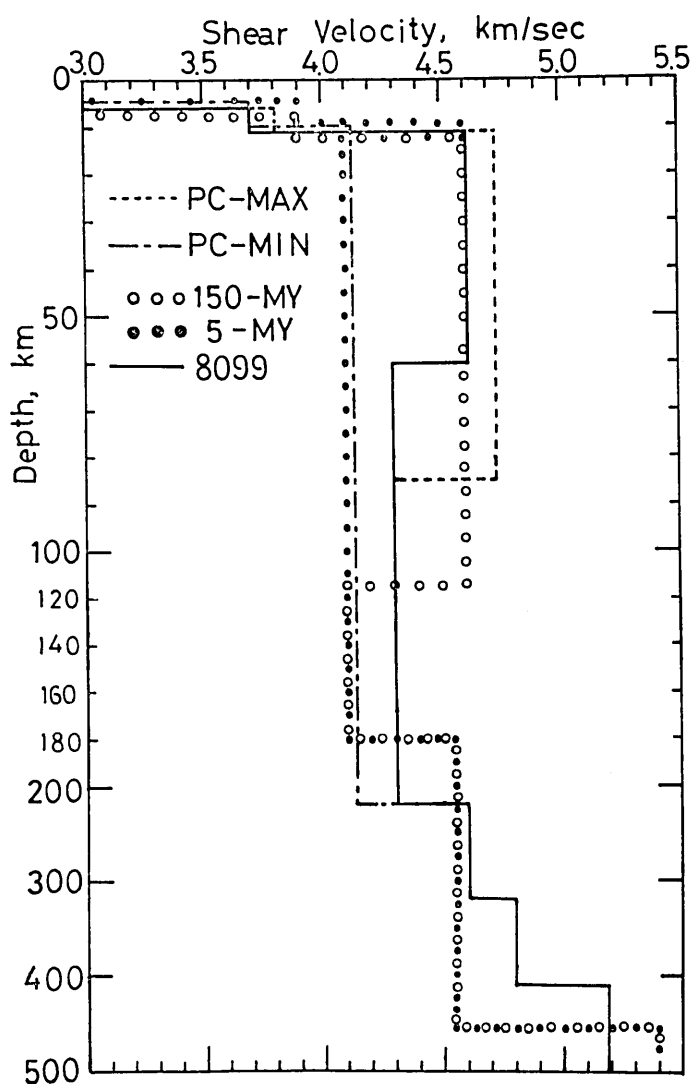


Fig. 6. Shear velocity distributions for the models PC-MAX and PC-MIN, which correspond to the regions (C) and (A) respectively. The distributions for the models 150-MY and 5-MY proposed by SCHLUE and KNOPOFF (1977), for the regions of the ages of 150 and 5 m.y., are also shown.

8. Discussion

Associated with the ocean-floor age, a set of upper mantle models in the Pacific are proposed by LEEDS, KNOPOFF and KAUSEL (1974) and SCHLUE and KNOPOFF (1976, 1977), using phase velocity data. Of the above models we will temporarily denote the Schlue and Knopoff's model for the youngest age of 5 m.y. as Model 5-MY and that for 150 m.y. as Model 150-MY (see Fig. 6). We notice that the shear velocity in the lid in the 150-MY is lower than the PC-MAX and that in the LVZ in the 5-MY than the PC-MIN. However, the shear velocity structures in the models 150-MY and 5-MY seem in some degree low to explain the group velocity characteristics for the oldest region for the periods 40~50 seconds and the youngest region for 40~70 seconds (Fig. 8).

In PC-MAX, the shear velocity in the lid is about 4.73 km/sec, slightly higher than that in the model 8099, which corresponds to the region of 85 m.y. (Table 3 and Fig. 6) and the model PC-MAX explained very well the velocity of the Airy-phase in the oldest region (Fig. 4). This some-

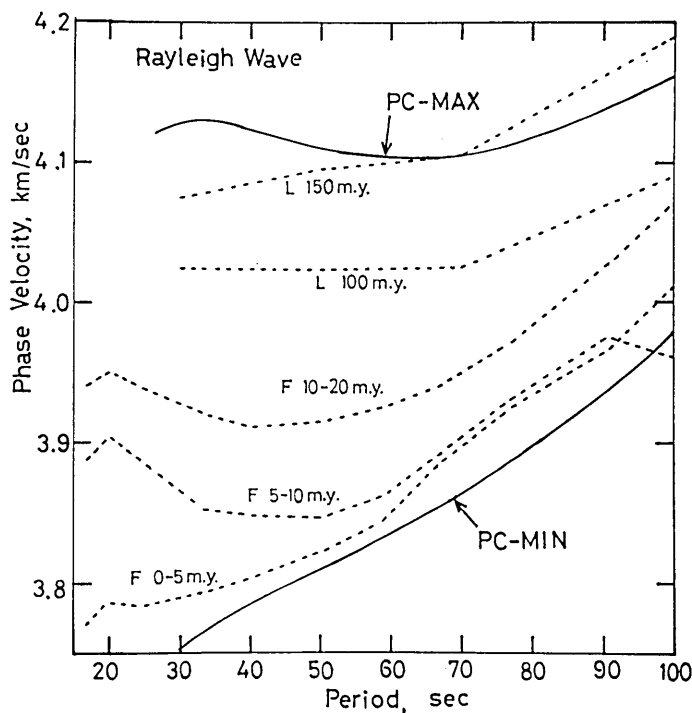


Fig. 7. Phase velocities (dotted lines) associated with the ocean-floor age, which were observed by L (LEEDS, 1975) and F (FORSYTH, 1975b). Calculated phase velocities are given by solid lines.

what high velocity of the shear wave in the lithosphere is in harmony with the observation of somewhat high velocities of the compressional wave (ASADA and SHIMAMURA, 1976) and the shear wave (SHIMAMURA, ASADA and KUMAZAWA, 1977) in the oceanic upper mantle in the Western Pacific.

Taking into account the cooling mechanism of the oceanic lithosphere (McKENZIE, 1967), the somewhat high shear velocity in the lithosphere of PC-MAX will be interpreted as the result of a cooling effect of the oldest lithosphere, because the compressional and shear velocities of mantle materials are expected to increase with the decrease of temperature (e.g., FUJISAWA, 1968).

Although the thickness of the oldest lithosphere in the model PC-MAX is about 30 km thinner than that in the model 150-MY (see Fig. 6), this estimation is concordant with a thickening plate model (KONO and YOSHII, 1975; YOSHII, KONO and ITO, 1976) which explains gravity anomalies,

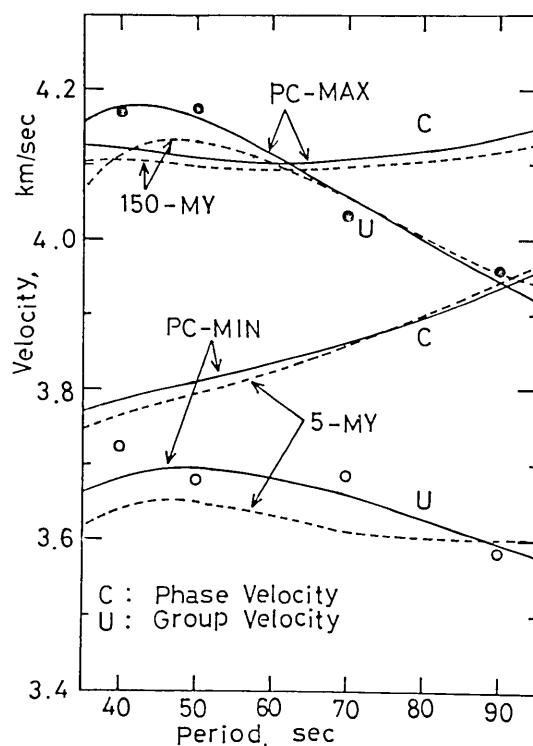


Fig. 8. Phase and group velocity curves calculated for the models PC-MAX and PC-MIN constructed from group velocity data and for the models 150-MY and 5-MY from phase velocity data. Group velocities for the oldest region of the age 150 m.y. or more (solid circles) and the youngest region of the age 0 m.y. (open circles) are taken from Fig. 5.

surface heatflow and other geophysical data.

In PC-MIN, the shear velocity in the LVZ is about 0.04 km/sec higher than that of 5-MY (Fig. 6), and this velocity distribution of PC-MIN is good for explaining both dispersion characteristics of group (Fig. 4) and phase (Fig. 7) velocities of Rayleigh waves for the youngest region.

9. Conclusions

Group velocities of Rayleigh waves in the Pacific have been newly calculated in terms of spherical surface harmonics for the period range 40 to 90 seconds (Fig. 2). A number of local dispersion characteristics of group velocities associated with the ocean-floor age have also been determined on the basis of the synthesized velocities (Fig. 5). Two upper mantle models, the PC-MAX for the oldest region of the age of 150 m.y. or more and the PC-MIN for the youngest region of the age of 0 m.y. have been constructed (Fig. 6).

It is understood that the model 8099 corresponds to the region of the age of 85 m.y., and the maximum thickness of the oldest lithosphere is at most 90 km (Fig. 4). The two models explain not only the dispersion characteristics of group velocities but also the phase velocities for the oldest and youngest regions (Fig. 7), and suggest that physical properties of the lithosphere and the asthenosphere vary with the ocean-floor age.

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12. 太平洋におけるレイリー波の群速度分布と 2つの上部マントルモデル

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表面球関数によって表現されているレイリー波の群速度分布が、周期 40, 70 及び 90 秒に対して新しく計算されている。海洋下上部マントルの横方向の不均質性が群速度分布図上に輪郭線で表わされ、最も若い地域と最も古い地域における 2つの上部マントルモデルが提唱されている。

地域的な群速度特性から、有名な海洋モデル 8099 が海洋底年代でおよそ 8500 万年、ハワイ島の東の地域に相当することが見い出されている。群速度は年代の最も若い地域で最も低く、約 1 億 5000 万年の最も古い地域で最も高い。これら 2つの地域間における群速度差は周期 40~50 秒で 0.5km/sec (約 13%) にも達する。

表面波の速度が年代と共に増加するのは、海洋性岩石圏が年代と共に厚くなっている事、岩石圏と低速層における S 波の速度が年代と共に増加している事等に帰因すると思われる。最も若い地域における低速層の S 波速度は 4.136 km/sec、最も古い地域における岩石圏のそれは 4.728 km/sec と見積られる。最も古い海洋性岩石圏の厚さは 85 ± 5 km であると推定される。
