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48. *Study on the Crust-mantle Structure in Japan.* Part 3, Analysis of Surface Wave Data.*

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Abstract

Phase velocities of Rayleigh waves for various regions in Japan have been determined by Aki and Kaminuma. In the present study, their results have been analyzed on the basis of the crust-mantle structures derived by the gravity indications.

The thickness of the intermediate layer, i. e. a layer just beneath the Moho discontinuity with comparatively low compressional wave velocity, has been examined.

The fitting of the theoretical dispersion curves to the observed data indicates either that the intermediate layer is thickest in the central mountain area, or that the shear velocity is very low in the layer in this area. In western Japan the intermediate layer appears to be slightly thicker than that in eastern Japan. The average thickness of the intermediate layer may be 40 km in Japan.

The lower phase velocity in central Japan can be explained by the increase in Poisson's ratio in the intermediate layer. The required increase in Poisson's ratio due to the temperature effect may physically be probable, though it has not been well established by laboratory experiments.

1. Data

The phase velocity of Rayleigh waves from the Samoa Shock (1957) and the Aleutian Shock of March 9, 1957 has been analysed by Aki[1], and Kaminuma and Aki[2]. They have obtained the phase velocities of Rayleigh waves for various regions in Japan and also the average value for Japan. Their results are summarized in Table 1 and Table 2 (see also Fig. 1 and Fig. 2). This data will be adopted in the present analysis.

* Communicated by T. HAGIWARA.

1) K. AKI, *Bull. Earthq. Res. Inst.*, **39** (1961), 255.
2) K. KAMINUMA and K. AKI, *ibid.*, **41** (1963), 243.

Table 1. The values of phase velocity C in various regions in Japan. (After Kaminuma and Aki)

Region	Wave No.	Period	C km/sec
1. S. Hokkaido	1	37.0 sec	3.71±0.25
	2	29.6	3.65±0.07
	3	25.8	3.58±0.08
	5	23.8	3.42±0.05
	7	22.0	3.42±0.18
2. Shinetsu	1	37.2	3.83±0.03
	2	29.1	3.64±0.08
	3	25.2	3.59±0.09
	5	23.2	3.58±0.05
	7	22.1	3.46±0.98
3. N. Kanto	1	36.3	3.88±0.03
	2	28.2	3.60±0.06
	3	25.3	3.57±0.08
	5	23.7	3.53±0.02
	7	21.6	3.55±0.29
4. S. Kanto	1	35.4	3.84±0.05
	2	28.6	3.76±0.07
	3	25.9	3.63±0.06
	5	23.9	3.50±0.09
	7	21.4	3.33±0.09
5. Chubu	1	40.1	3.54±0.09
	2	29.9	3.67±0.10
	3	26.7	3.61±0.08
	5	24.0	3.54±0.12
	7	21.9	3.62±0.17
6. Hokuriku	1	38.3	3.86±0.19
	2	30.8	3.54±0.10
	3	26.2	3.46±0.07
	5	23.7	3.41±0.14
	7	21.9	3.26±0.16
7. Kii	1	39.0	3.91±0.20
	2	30.6	3.72±0.10
	3	26.7	3.70±0.08
	5	24.1	3.72±0.10
	7	21.9	3.54±0.07
8. Chugoku	1	41.3	3.78±0.11
	2	32.1	3.72±0.06
	3	27.4	3.76±0.09
	5	24.8	3.65±0.10
	7	23.0	3.61±0.15
9. Shikoku	1	40.2	3.72±0.13
	2	31.4	3.74±0.04
	3	26.8	3.64±0.08
	5	24.4	3.74±0.05
	7	23.2	3.70±0.07
10. Bungo	1	40.8	3.79±0.09
	2	32.7	3.82±0.06
	3	28.2	3.72±0.07
	5	25.3	3.64±0.17
	7	23.3	3.60±0.31

Although the probable errors in the values of the phase velocity are considerably large for each region, particularly for the waves No. 1 and No. 7, still we can interpolate the values of the phase velocity with the period of 30 sec with probable errors of about 0.05 km/sec. In Table 3, the interpolated phase velocities of Rayleigh

Table 2. Average phase velocity in Japan except south Hokkaido. (After Kaminuma and Aki)

Wave No.	Period	C km/sec
1	38.3 sec	3.79±0.04
2	30.3	3.69±0.03
3	26.4	3.63±0.03
5	24.1	3.59±0.04
7	22.1	3.52±0.05

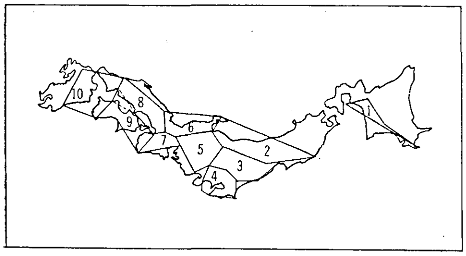

Fig. 1. Division of stations into 10 groups; (after Kaminuma and Aki) 1. southern Hokkaido; 2. Shinetsu; 3. northern Kanto; 4. southern Kanto; 5. Chubu; 6. Hokuriku; 7. Kii; 8. Chugoku; 9. Shikoku 10. Bungo.

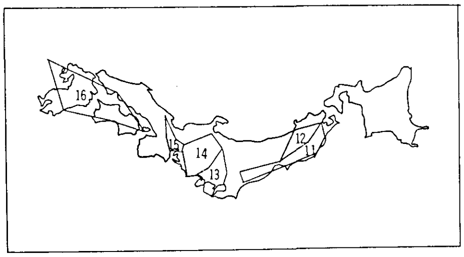

Fig. 2. Division of stations into 6 groups; (after Aki). 11. eastern Tohoku; 12. western Tohoku; 13. south-western Kanto; 14. Chubu; 15. Kinki; 16. south-western Japan.

Table 3. The phase velocity of Rayleigh waves with a period of 30 sec (after Kaminuma and Aki) and the crustal thickness derived from the gravity analysis (Kanamori) for various regions in Japan.

No.	Region	$C(T=30\text{sec})$	Elevation	Crustal thickness
1.	S. Hokkaido	3.65 km/sec.	229m	30.6 km
2.	Shinetsu	3.65	243	29.6
3.	N. Kanto	3.65	669	30.1
4.	S. Kanto	3.78	173	30.1
5.	Chubu-1	3.67	860	34.6
6.	Hokuriku	3.55	231	31.2
7.	Kii	3.72	391	30.3
8.	Chugoku	3.74	217	30.6
9.	Shikoku	3.71	−16	29.6
10.	Bungo	3.76	133	31.9
11.	E. Tohoku	3.77	283	25.6
12.	W. Tohoku	3.76	365	28.8
13.	S. W. Kanto	3.56	553	32.5
14.	Chubu-2	3.45	953	33.9
15.	Kinki	3.75	274	31.4
16.	S. W. Japan	3.72	158	31.3

waves with the period of 30 sec for each region are tabulated. The values determined by Aki[3] are also included in Table 3 (No. 11～16).

2. Analysis

For the interpretation of the phase velocity data, it is necessary to have a starting point where the theoretical dispersion curves for crust-mantle models are known. For the crustal model, we have adopted, according to the analysis made in Part 2 of this study[4], the structures J-VI and J-VII as given by Fig. 3 a, b. The difference between J-VI and J-VII models lies in the value of the velocity in *Layer*-2. In both models the

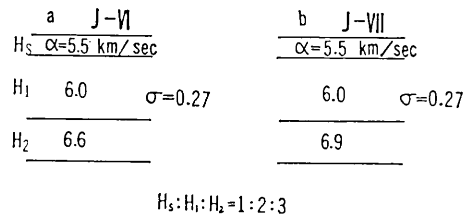

Fig. 3. Crustal models J-VI and J-VII. α is compressional wave velocity, and σ; Poisson's ratio.

Table 4. Layer parameters for J-VI-0, J-VI-1, I-VI-2, J-VI-4, J-VII-0, J-VII-1, J-VII-2 and J-VII-4 models.

Layer	α km/sec	β km/sec	ρ g/cm³	σ	Thickness
Superficial	5.50	3.08	2.76	0.27	H_s
1	6.00	3.36	2.76	0.27	H_1
2	6.60	3.70	3.00	0.27	H_2
Intermediate	7.50	4.20	3.19	0.27	H_I
Normal Mantle	8.10	4.54	3.27	0.27	∞

Layer	α km/sec	β km/sec	ρ g/cm³	σ	Thickness
Superficial	5.50	3.08	2.76	0.27	H_s
1	6.00	3.36	2.76	0.27	H_1
2	6.90	3.87	3.00	0.27	H_2
Intermediate	7.50	4.20	3.19	0.27	H_I
Normal Mantle	8.10	4.54	3.27	0.27	∞

Model	H_s/H_c	H_1/H_c	H_2/H_c	H_I/H_c
J-VII-0, J-VI-0	1/6	3/6	2/6	0
J-VII-1, J-VI-1	1/6	3/6	2/6	4/6
J-VII-2, J-VI-2	1/6	3/6	2/6	8/6
J-VII-4, J-VI-4	1/6	3/6	2/6	∞

$H_c = H_s + H_1 + H_2$

3) K. AKI, *loc. cit.*, 1).

4) H. KANAMORI, *Bull. Earthq. Res. Inst.*, **41** (1963), 761-779.

superficial layer has been assumed to be present allowing for the decrease in the wave velocity of unconsolidated sediment. For the upper mantle structure, we will introduce an intermediate layer whose thickness has not been determined and will be taken as a parameter in the later analysis. Varying the thickness of the intermediate layer H_I from zero to infinity, we will obtain crust-mantle models J-VI-0, J-VI-1, J-VI-2, J-VI-4, J-VII-0, J-VII-1, J-VII-2 and J-VII-4 on which the calculation will be based. The layer parameters for these models are given in Table 4. The computations have been performed by a computer progam developed by Takeuchi, Saito and Kobayashi[5] and also by the functions $A\alpha(\sigma\cdot\rho)$ etc. given by Kanamori[6]. The computed dispersion curves are

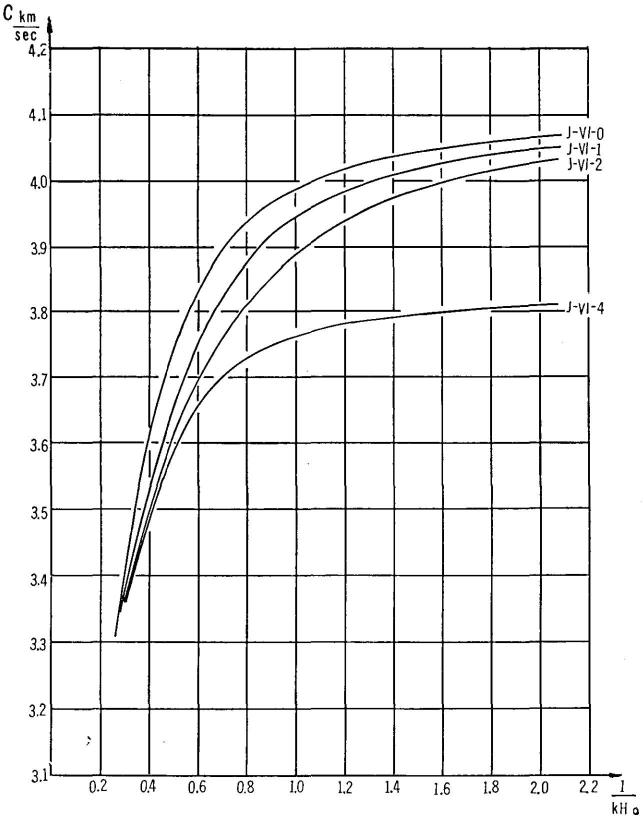

Fig. 4. Phase velocity dispersion curves of Rayleigh waves for crust-mantle models J-VI-0, J-VI-1, J-VI-2 and J-VI-4. k is the wave number and H_c is the total crustal thickness (i. e. $H_c=H_s+H_1+H_2$).

5) H. TAKEUCHI, M. SAITO and N. KOBAYASHI, *Zisin*, **14** (1961), 217, (in Japanese).
6) H. KANAMORI, *Bull. Earthq. Res. Inst.*, **41** (1963), 781-800.

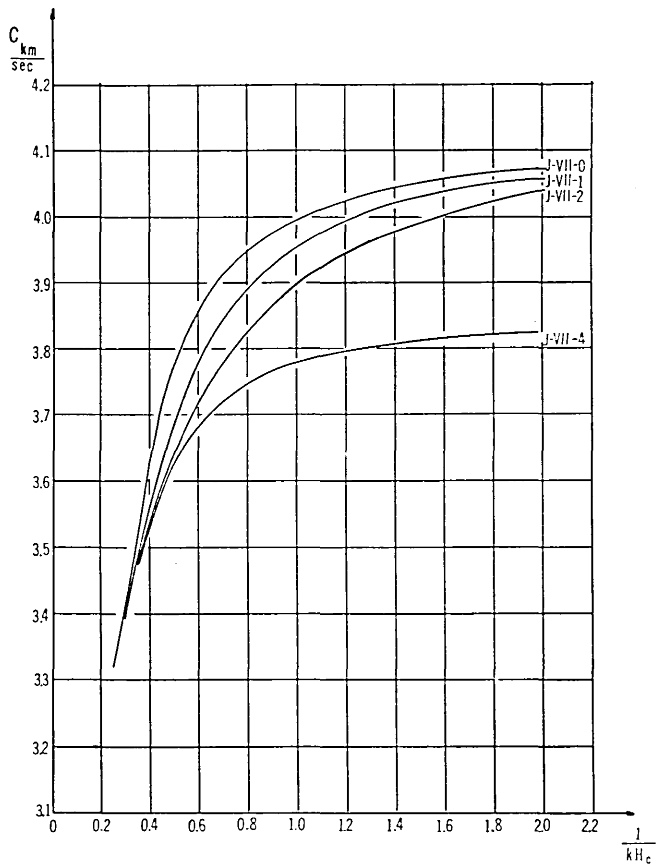

Fig. 5. Phase velocity dispersion curves of Rayleigh waves for crust-mantle models J-VII-0, J-VII-1, J-VII-2 and J-VII-4. k is the wave number and H_c is the total thickness of the crust (i.e. $H_c=H_s+H_1+H_2$).

shown in Fig. 4 and Fig. 5 where the ordinate is the phase velocity C and the abscissa $1/kH$ where k is the wave number and $H_c=H_s+H_1+H_2$, the crustal thickness.

As can clearly be seen in Table 1, the observed phase velocity for each region has probable errors of an appreciable amount and the direct use of this data for deducing the crustal structure does not appear to be legitimate. Therefore, we will take the average value of the regions 2, 3 and 4 in Table 1 as a representative value for eastern Japan, that of the regions 5 and 6 as the value for central Japan, and that of the regions 7, 8, 9 and 10 for western Japan. The resulting average phase velocities are tabulated in Table 5.

Table 5. Average phase velocity of Rayleigh waves for southern Hokkaido, eastern Japan, central Japan and western Japan.

Region	Wave No.	Period	C km/sec.
southern Hokkaido	1	37.0 sec.	3.71 km/sec.
	2	29.6	3.65
	3	25.8	3.58
	5	23.8	3.42
	7	22.0	3.42
eastern Japan	1	36.3	3.84
	2	28.6	3.66
	3	25.5	3.60
	5	23.6	3.54
	7	21.7	3.45
central Japan	1	39.2	3.70
	2	30.4	3.60
	3	26.5	3.52
	5	23.9	3.47
	7	21.9	3.44
western Japan	1	40.3	3.80
	2	31.7	3.75
	3	27.3	3.71
	5	24.7	3.69
	7	22.9	3.61

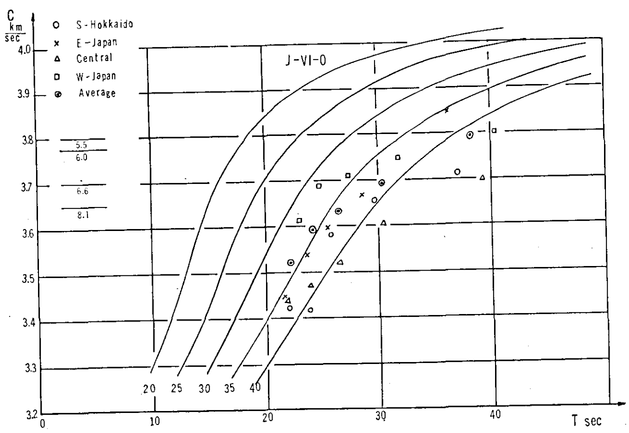

Fig. 6. Phase velocity curves of J-VI-0 model.

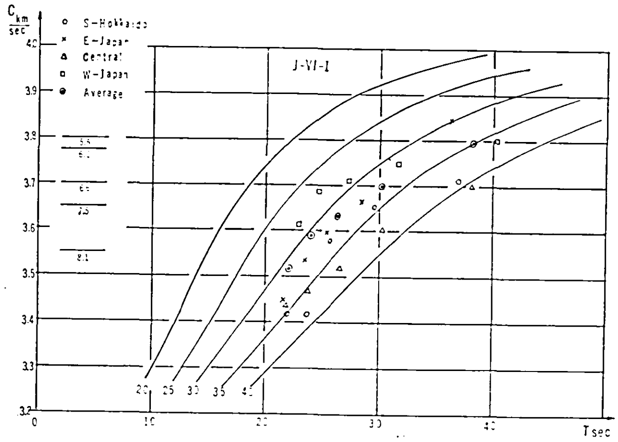

Fig. 7. Phase velocity curves of J-VI-1 model.

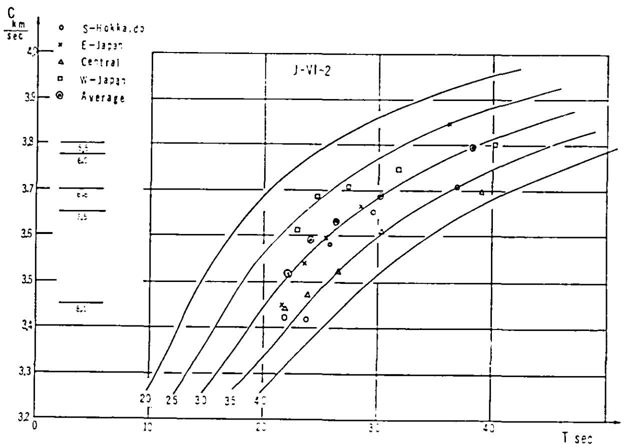

Fig. 8. Phase velocity curves of J-VI-2 model.

In Fig. 6, 7, 8 and 9, the dispersion curves for J-VI-0, J-VI-1, J-VI-2 and J-VI-4 models, plotted with the phase velocity data given above, are shown with the period T as the abscissa and the crustal thickness H_c as a parameter. In those figures the average phase velocities in Japan which are given in Table 2 are included. Although probable errors should be allowed for in the interpretation, it can be said, at least qualitatively, that the phase velocity dispersion in central Japan is in better agreement with the dispersion curves of J-VI-4 or J-VI-2 model than with those of J-VI-0 and J-VI-1 models. On the other hand, J-VI-0 or J-VI-1 model can explain the velocity dispersion

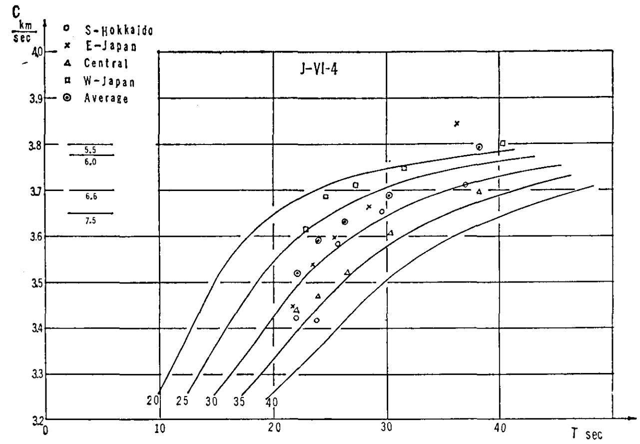

Fig. 9. Phase velocity curves of J-VI-4 model.

in eastern Japan much better than J-VI-2 or J-VI-4 model. Similarly, the velocity dispersion for western Japan and southern Hokkaido seems to be well explained by the models which have the thicker intermediate layer.

The crustal thickness in each area could be determined from the above analysis provided one of the crust-mantle models is adopted for each region. Although the thickness dotermination depends appreciably on the model postulated, it can still be said from the above analysis that the crustal thickness is about 32～35 km for central Japan, 30～33 km for eastern Japan, 23～28 km for western Japan and 30～35 km for southern Hokkaido. These values are in general agreement with those obtained by the gravity analysis made in Part 2 of this study allowing for the comparatively large probable errors in the phase velocity data and other uncertain factors involved in the thickness determination by both gravity and surface wave studies.

The selective correspondence of the velocity dispersion in different regions to the different crust-mantle models, and the plausible values of the crustal thickness determined therefrom lead us to the conclusion that the intermediate layer is very thick in the central part of Honshu Island and also it may be comparatively thicker in western Japan than in eastern Japan. In southern Hokkaido it could be thought, but with less reliability, that the intermediate layer may be considerably thick. The dispersion of the average phase velocity for Japan, except Hokkaido, is in best agreement with the dispersion curve of J-VI-2 model having

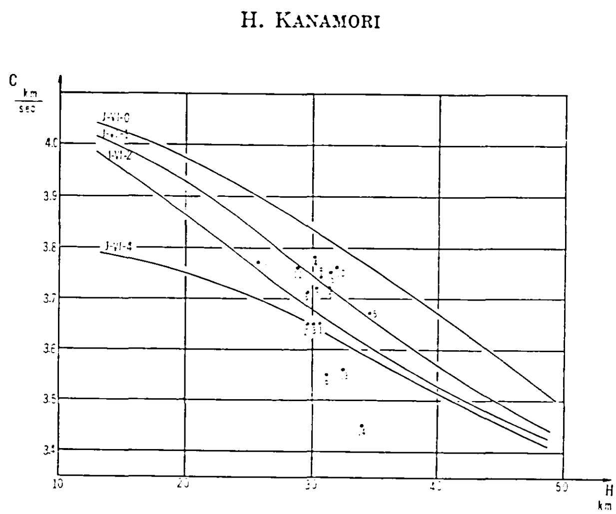

Fig. 10. Relation between the phase velocity with a period of 30 sec and the crustal thickness derived from the reduced Bouguer anomalies (topographic height being allowed for). The number of each point indicates the number of the corresponding region tabulated in Table 3. Solid lines show the relation theoretically expected from the crust-mantle models J-VI-0, J-VI-1, J-VI-2 and J-VI-4.

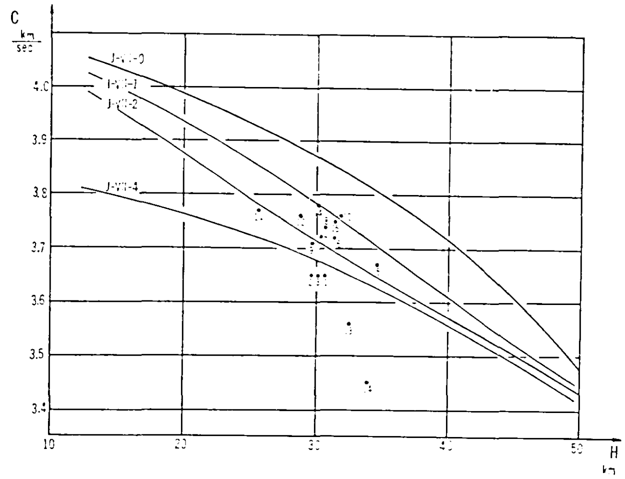

Fig. 11. Similar relation as given in Fig. 10 for the crust-mantle models J-VII-0, J-VII-1, J-VII-2 and J-VII-4.

a crustal thickness of H_c=30 km. This suggests that the average thickness of the intermediate layer in Japan is about 40 km. For comparison, if we take the mean value of the depth of Moho in Japan determined from the gravity indications as shown in Table 4 of Part 2 of this study, the resulting mean depth is 29.8 km (excluding Hokkaido). This is highly consistent with the value of H_c just obtained.

As an alternative approach to these facts, the relation between the observed phase velocity with the period $T=30$ sec and the crustal thickness H_c determined by the gravity analysis (topographic height, being allowed for) has been examined. In Fig. 10. and Fig. 11, the points indicate the phase velocity and the crustal thickness for every region given by Table 3, and the solid curves show the relation theoretically anticipated from the dispersion curves for various crust-mantle models given by Fig. 4 and Fig. 5. It can be seen from Fig. 10 and Fig. 11 that J-VI-0 and J-VII-0 models, which have no intermediate layer, do not appear to be appropriate. Most of the points fall between the curves of J-VII-1 and J-VII-2 models indicating that the thickness of the intermediate layer is about 20~40 km almost everywhere in Japan. It should be noted here that the points 6, 13 and 14 deviate appreciably, even from the curve of the extreme model J-VII-4. These points represents the values for central Japan and it may be said that in these regions the mean shear velocity in the intermediate layer should be lower than in the rest of the area. The points 1, 2 and 3 also seem to indicate either that the intermediate layer is thicker or that the mean shear velocity in the layer is lower in these regions. These are qualitatively in good agreement with the previous results obtained from the curve fitting of the dispersion data.

3. Intermediate layer

In the preceding section, an intermediate layer just beneath the Moho discontinuity, in which the compressional wave velocity is taken to be 7.5 km/sec as suggested by the explosion studies, was assumed to be present. The preceding analysis of the surface wave data has indicated the thickening of the intermediate layer towards central Japan (central mountain area) and also the presence of a thicker layer in western Japan compared to that in eastern Japan.

However, as far as the surface wave study is concerned, it is not always possible to discriminate a layer in which both the compressional and shear velocity are low from one with a low shear velocity but with a normal compressional wave velocity. Consequently, the intermediate layer discussed above should be understood as a layer in which the mean shear velocity is lower than normal, and little can be said as to the change in the compressional wave velocity. In other words, a layer of high Poisson's ratio with a normal compressional wave velocity has approximately the same influence on the velocity dispersion of surface wave as that of low compressional wave velocity with the normal Poisson's ratio. Merely for a conventional purpose, we have adopted the latter model in the previous analysis but we can reasonably replace it by the former or by a composite model.

In order to examine quantitatively the effect of the various elastic parameters on the velocity dispersion of Rayleigh waves, we have calculated the increment ΔC in the phase velocity C due to hypothetical changes in the elastic parameters at various depths. The calculations can be proceeded along the general lines of the method given by Kanamori[7]. Although the crust-mantle model on which the calculation is based is not exactly the same as the one adopted in the present

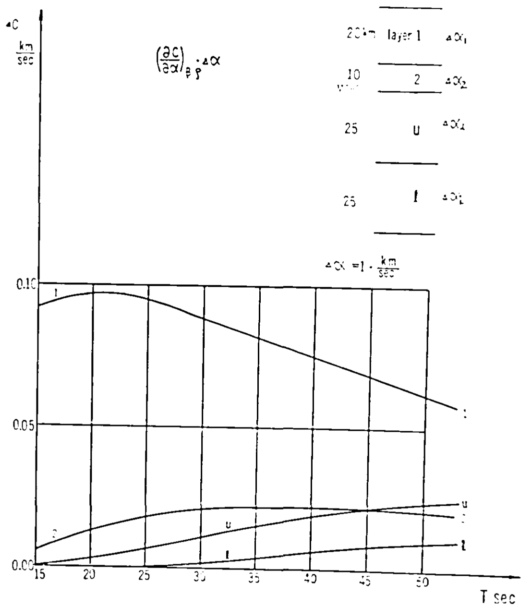

Fig. 12. Increment ΔC in phase velocity of Rayleigh waves due to a hypothetical change of compressional wave velocity $\Delta\alpha$ of 1 km/sec..

The crust-mantle section is divided into four layers, 1, 2, u, and l. Curve 1 due to the change in layer 1; Curve 2, due to the change in layer 2; Curve u, due to the change in layer u; Curve l, due to the change in layer l. Shear velocity and density are kept constant.

7) H. KANAMORI, *Bull. Earthq. Res. Inst.*, **41** (1963), 781-800.

study, no appreciable error would result therefrom as demonstrated in Reference 7). To examine the effect from layers at various depths we have temporarily divided the crust-mantle model into four layers, *Layer*-1, *Layer*-2, *Layer-u* and *Layer-l*. *Layer*-1 and *Layer*-2 would correspond to the layers above and below the Conrad discontinuity so to speak, and have a thickness of 20 km and 10 km respectively. *Layer-u* and *Layer-l* have a thickness of 25 km and represent the upper and lower half of the intermediate layer in the mantle. Fig. 12 shows the phase velocity increment ΔC in kilometers per second for the hypothetical changes of 1 km/sec in compressional wave velocity in *Layer*-1 $\Delta\alpha_1$;

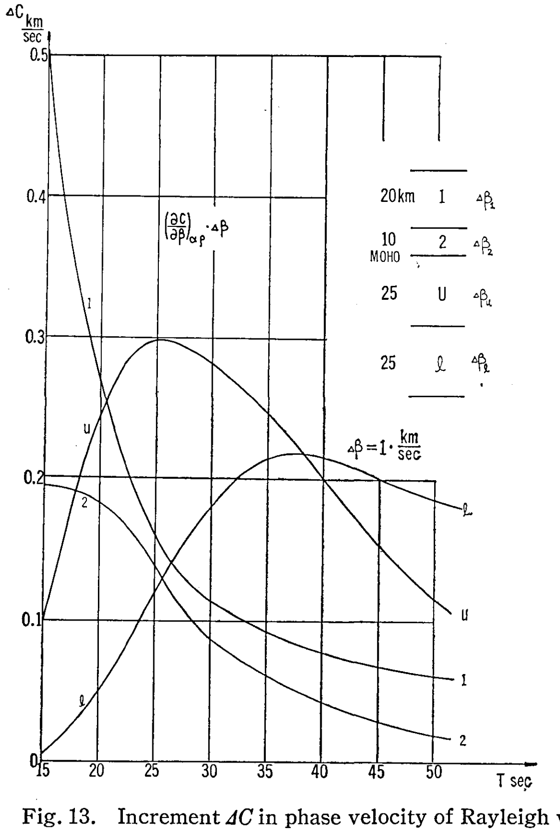

Fig. 13. Increment ΔC in phase velocity of Rayleigh waves due to a hypothetical change of 1 km/sec in shear velocity.

Compressional wave velocity being kept constant. Curve 1, due to the change in layer 1; Curve 2, due to the change in layer 2; Curve *u*, due to the change in layer *u*; Curve *l*, due to the change in layer *l*.

Layer-2, $\Delta\alpha_2$; *Layer-u*, $\Delta\alpha_u$; and *Layer-l*, $\Delta\alpha_l$ with the constant shear velocity and density. Although the layer thickness is not taken uniformly, it could be seen that the effect of the change in the deeper layers is very small compared with that in *Layer*-1. Then, we can conclude that the value of the compressional wave velocity in the intermediate layer has little effect on the phase velocity. In Fig. 13, similar curves are shown for the changes in the shear velocity, the compressional wave velocity and density being kept constant. It should be noted here that, in contrast with Fig. 12, it is remarkable that the effect from the deeper layers is very large for the waves with a periob of about 25~40 sec. This shows that if the shear velocity is decreased dy 0.2 km/sec everywhere within the intermediate layer, the phase velocity with a period of 30 sec would be decreased by about 0.1 km/sec. The effect of the shear velocity change is shown by alternative ways in Fig. 14 and Fig. 15. In Fig. 15, it can clearly be seen that an increase by 0.04 in the Poisson's ratio in the intermediate layer would result in a decrease of 0.1 km/sec in the phase velocity with a period of 30 sec.

With these results, it is of some interest to re-examine the results shown by Fig. 10 and Fig.11. In these figures, the discrepancies between the observed phase velocities in central Japan and the normal value could be regarded as 0.05~0.2 km/sec. From the above analysis, these discrepancies can quantitatively be explained by a change in the Poisson's

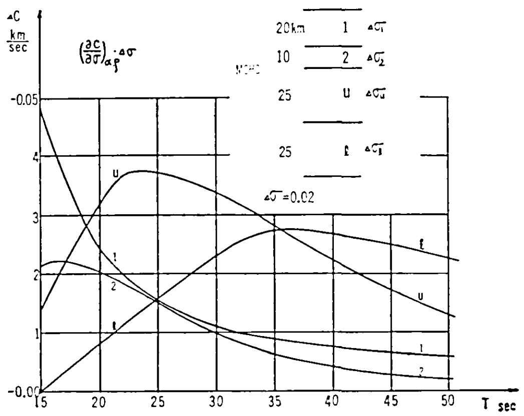

Fig. 14. Increment ΔC in phase velocity of Rayleigh waves due to a change in Poisson's ratio of 0.02. Curve 1, due to the change in layer 1; Curve 2, due to the change in layer 2; Curve *u*, due to the change in layer *u*; Curve *l*, due to the change in layer *l*.

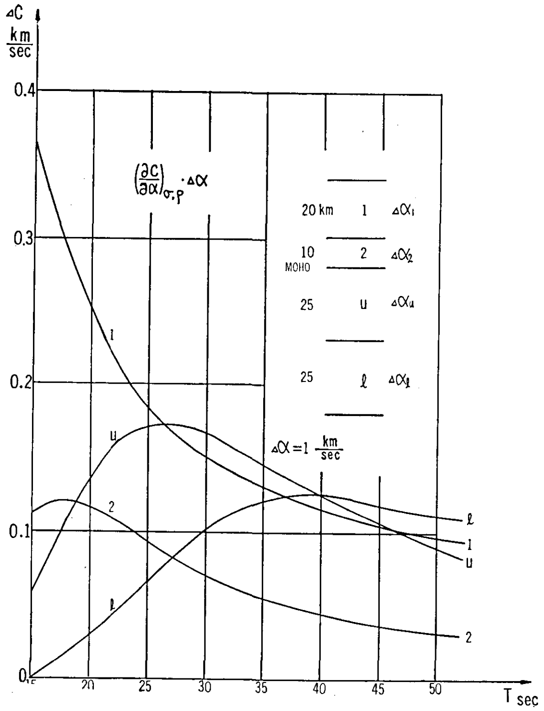

Fig. 15. Increment ΔC in phase velocity of Rayleigh waves due to a change in compressional wave velocity 1 km/sec with constant Poisson's ratio and density. Curve 1, due to the change in layer 1; Curve 2, due to the change in layer 2; Curve *u*, due to the change in layer *u*; Curve *l*, due to the change in layer *l*.

ratio in the intermediate layer of 0.02 to 0.08. The Poisson's ratio does not appreciably depend upon pressure (Birch[8]), and its dependence upon temperature has not been thoroughly investigated. But Poisson's ratio of the order of 0.35 does not appear to be physically improbable at elevated temperatures.

Although the low compressional wave velocity in the upper part of the mantle in Japan has been strongly implied by the explosion studies, there may be no compelling reason for insisting either on its continuation into the deeper part or otherwise. If the layer of low compressional wave velocity were very thick it would yield regional negative anomalies of appreciable amount in the gravity field, provided the fixed relation

8) F. BIRCH, *J. Geophys. Res.*, **66** (1961), 2199.

between ρ and α is assumed. However, in the central mountain area where the intermediate layer has been suspected of being very thick, negative gravity anomalies of excessively larger amount than those expected from the topography and the crustal thickness are seen. At first sight, this seems to be in favour of the model with the larger Poisson's ratio and the normal compressional wave velocity at the deeper part of the intermediate layer. Yet, if there is an upward bulging of the Conrad discontinuity increasing the mean crustal density, as in the mountain regions in central Asia[9], it might compensate for the mass deficiency in the mantle without giving any excessive gravity anomalies. Thus, the possibility of the continuation of the layer of low compressional wave velocity into the deeper part beneath the central mountain area cannot be ruled out.

Further detailed study without any more geophysical and laboratory data would be premature.

4. Discussion and conclusions

In Part 2 of this study we concluded the presence of what might be referred to as the Conrad discontinuity but whether it is a well defined acoustic boundary or not is uncertain. The transition may be rather gradual, but still it can be said that in the lower part of the crust, the seismic velocity is about 6.5~7 km/sec and the mean density of the crust may not differ appreciably from that of the continental value.

The comparatively low compressional wave velocity in the upper part of the mantle, suggested from the surface refraction studies, appears to be significant. This low velocity, however, does not appear to be representative for the entire vertical section of the upper mantle in Japan.

From the surface wave data given by Aki[10], and Kaminuma and Aki[11], the intermediate layer, which has been defined as one just beneath the Moho with low compressional and shear velocities, appears to be thicker in western Japan than in eastern Japan. Actually, it may be thickest in the central mountain area. However, as mentioned earlier, other solutions which are seismically equivalent to the model postulated above may be possible. It could be said, with a certain degree of confidence,

9) G. P. WOOLLARD, *J. Geophys. Res.*, **64** (1959), 1521.
10) K. AKI, *loc. cit.*, 1).
11) K. KAMINUMA and K. AKI, *loc. cit.*, 2).

that the upper boundary of the intermediate layer is acoustically well defined as indicated by the rather distinct arrival of the refracted waves from this layer, but whether its lower boundary is a sudden discontinuous surface or a transitional zone is quite uncertain. The latter may quite possibly be the case. What can most safely be said is that the average shear velocity over forty or so kilometers of the vertical section just beneath the Moho in the central mountain area is significantly lower than the normal.

The physical and geological properties of the intermediate layer still remain uncertain. This layer may be one of peridotitic material partly serpentinized or a peridotitic layer with the lower velocity gabbroic material as suggested by Kuno[12]. A further possibility is the anomalous increase in the Poisson's ratio in this layer due to the temperature and pressure effect. Laboratory experiments performed by Verma[13] have shown large elastic anisotropy of olivine crystals which could also be a cause of low seismic velocity in the layer.

It should be emphasized that more laboratory experiments should be performed related to the dependence of Poisson's ratio on temperature and the elastic anisotropy with its temperature dependence. Study of the distribution of the serpentinized peridotite in Japan would be of much interest if the sampling could be properly made.

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48. 日本の地殻とマントル上層部の構造
Part 3. 表面波の解析

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日本の各地域における Rayleigh 波の位相速度は安芸，神沼らによつて求められている．この論文では，これらの Data を用いて，Part 2 で考えた Moho のすぐ下の低速度層（ここではこれを intermediate layer と呼ぶことにする）についての考察を行なつた．intermediate layer の厚さをいろいろに変えたモデルについて位相速度法を適用すると，位相速度の分散の仕方とそれによつて定まる地殻の厚さから考えて，intermediate layer は中部日本では厚く，東北日本ではうすいように考えられる．また西南日本では東北日本に較べてやや厚いように見える．さらに日本の平均としては，この intermediate layer は約 40 km 位の厚さと考えられる．しかし，これらの結論は，位相速度の測定に含まれている誤差によつてかなり影響される可能性があるので，別の方法として，比較的精

12) H. Kuno, *Personal Communication.*

13) R. K. Verma, *J. Geophys. Res.*, **65** (1960), 757.

度の良い，周期 30 sec の波の位相速度と，Part 2 で定められた Moho の深さとの比較を行なつた．この結果も定性的には前に得られた結果と一致する．このようなことから考えて，日本では，intermediate layer は平均的にはクラストの厚さと同じ位の厚さで，中部日本で比較的厚いということができる．

このような intermediate layer の物理的，地質的性質はよく判らないが，表面波による限り，この層が P 波の速さも S 波の速さも遅い層であるか，あるいは P 波の速さは普通で，S 波だけが遅い層であるかは区別できない．この論文で用いたモデルは P 波，S 波が共に遅いモデルを用いたが，これはあくまで便宜的なものである．

P 波，S 波の速さやポアソン比がどの位の値をとれば，日本における観測結果を満足するかを定量的に議論した．これによると，intermediate layer の中で Poisson 比が 0.3～0.35 位の値をとれば，観測結果を十分説明することができる．これらのことから考えて，この intermediate layer としては次のようなものが考えられる．

1) 一部分 serpentine になつた peridotitic な層
2) peridotite の層の中に gabbroic なものが patch 状に含まれている．
3) 局部的に温度が高く，そこで Poisson 比が非常に大きくなつている．
4) dunite 中の olivine が全体として弾性的異方性をもつている．

実際に，これらのいずれであるかを確かめるためには，高温，高圧における弾性定数特に Poisson 比の変化，olivine の結晶の弾性的 anisotropy の圧力による変化，日本における serpentinized peridotite の分布などをさらに調べる必要がある．