4. *Relation between the Gravity Anomalies and the Corresponding Subterranean Mass Distribution. (VI.)*

By Chuji TSUBOI and Seiti YAMAGUTI,

Earthquake Research Institute.

(Read June 20, 1940.—Received Dec. 20, 1940.)

In his earlier papers[1], one of the present writers developed a direct method, with the aid of which it is possible to estimate, from the gravity anomalies that are observed in a certain region, the responsible subterranean mass distribution. In subsequent papers, the method was successfully applied for studying the geophysical structure of the earth in various localities of the world where gravity data for such studies are available. Particularly in the fourth and fifth papers of the series[2], the method was applied for studying the isostatic conditions of the earth's crust in the United States of America. The thickness of the isostatic earth's crust d, the degree of regionality of isostasy R, and the undulation of the isostatic geoid in the U.S.A. could be found directly from the Bouguer gravity anomalies observed in that country. The present paper, which is the sixth of the series, similarly deals with that part of the Dutch East Indies, bounded by latitudes 0° and 10°S and longitudes 118°E and 132°E, approximately $1000 \times 1400 \text{km}^2$ in area. Since for the purpose of the present study, the same method will be followed as in the previous ones, no detailed explanation of it will be repeated.

Being situated in the eastern part of the Dutch East Indies, most of the area to be studied belongs to the Banda Sea, including the Celebes, Flores, Timor, Ceram, and many other islands. The gravity anomalies in this area was measured by Vening Meinesz during his famous submarine expeditions. The extremely interesting facts as disclosed by these measurements concerning the geophysical structure in this area

1) C. TSUBOI and T. FUCHIDA, *Bull. Earthq. Res. Inst.*, **15** (1937), 636; **16** (1938), 273.
C. TSUBOI, *ibid.*, **15** (1937), 650; **17** (1939), 351; *Proc. Imp. Acad. Tokyo*, **14** (1938), 170.

2) C. TSUBOI and others, *Bull. Earthq. Res. Inst.*, **18** (1939), 385.
C. TSUBOI, *ibid.*, **18** (1940), 384.

have already been discussed by Vening Meinesz himself and many others. The area to be studied in the present paper is exactly where the belt of large negative gravity anomalies that was found by Vening Meinesz changes its trend acutely into a NS direction after running in an EW direction off the southern coasts of Java, Sumatra, and other islands of the East Indian Archipelago.

First of all, it is important that the earth's crust in this area is, very roughly speaking, in isostatic equilibrium. If the Bouguer gravity anomalies in this area are plotted against the depths of the sea where the anomalies were measured, Fig. 1 is obtained, in which is an unmistakable tendency of the anomaly $\Delta g_0''$ to increase with the depth $(-H')$. The least square calculations show that the relation between

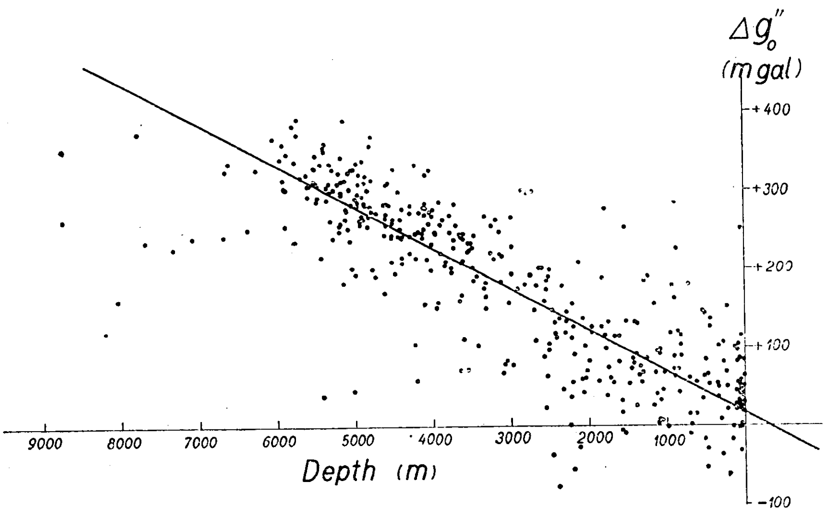

Fig. 1. Relation between the Bouguer Gravity Anomalies and Depth.

the two quantities is given by

$$\Delta g_0''(\text{mgal}) = 15 - 0{\cdot}05\, H'(\text{m}).$$

On the other hand, using the notations as shown in Fig. 2, perfect Airy isostasy implies that

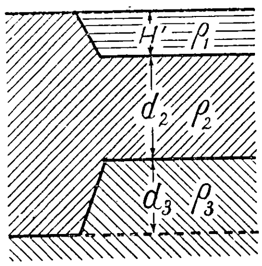

Fig. 2.

$$\rho_1 H' + \rho_2 d_2 + \rho_3 d_3 = \rho_2 (H' + d_2 + d_3),$$

where ρ_1, ρ_2, and ρ_3 are respectively the densities of the sea-water, of the earth's crust and of the subcrustal material underlying it, whence we have

$$d_3 = \frac{\rho_2 - \rho_1}{\rho_3 - \rho_2} H'.$$

The Bouguer anomaly as observed on the surface of the sea will then be

$$\begin{aligned} \Delta g_0'' &= 2\pi k^2 (\rho_3 - \rho_2) d_3 \\ &= 2\pi k^2 (\rho_2 - \rho_1) H' \end{aligned}$$

provided isostasy is perfect. Equating $2\pi k^2(\rho_2 - \rho_1)$ with the numerical constants $0{\cdot}05 \times 10^{-5}$, which was found by the least square calculation, and putting

$$\rho_1 = 1{\cdot}0,$$

then from

$$2\pi k^2 (\rho_2 - \rho_1) = 0{\cdot}05 \times 10^{-5}$$

we get

$$\rho_2 = 2{\cdot}2$$

which value is not unreasobable, although a little too small. At any rate, it is important that even in those areas, such as the Dutch East Indies, in which intense tectonic disturbances are believed to have taken place, isostasy still holds approximately. Those who state the contrary forget the fact that the gravity anomalies would be at least a few time greater if isostasy was altogether ignored. It is true that isostatic anomalies are large in these areas, but large isostatic anomalies do not necessarily imply absolute absence of the isostatic state.

Assuming that Airy's isostasy holds approximately in this area, the first requisite in this study is to determine the thickness of the earth's crust under that asssumption. As was shown in the previous papers, this can be done by comparing the Fourier coefficients for the topographical relief and for the observed Bouguer gravity anomalies in the area under study. In the present case, the whole range of area to be studied was taken as $\pi \times \pi$, and since the symmetric images of the distributions to be analysed into the Fourier series were added beyond that range, they are expressed by a cosine series, such as

$$H(xy) = \sum\sum H_{mn} \cos mx \cos ny,$$

$$\Delta g_0''(xy) = \sum\sum B_{mn} \cos mx \cos ny.$$

In executing the Fourier analysis of the topographical relief, due reductions were made for the effect of the sea-water. Thus the actual

Table I. Fourier Coefficients H_{mn} for the Topographical Relief. (in 10 m.)

n \ m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	−98·7	38·1	42·4	−12·3	−19·8	−19·5	3·2	− 6·9	− 5·1	−11·1	− 0·8	4·0	17·9	− 8·3	13·3	6·4	3·4	− 2·8	0·8
1	22·6	16·1	36·8	− 4·3	−53·0	−14·9	− 6·2	−10·7	− 5·4	− 5·0	−12·8	6·8	3·1	0·8	11·9	16·3	10·0	− 1·6	− 1·1
2	45·5	−61·3	−16·1	− 1·4	16·2	4·5	−22·4	− 2·6	1·2	21·3	− 8·5	11·1	− 3·3	8·6	− 2·7	8·7	− 6·8	− 1·8	4·8
3	−41·5	7·4	−45·1	− 4·5	17·8	16·6	12·9	7·7	1·9	11·7	5·5	− 5·2	11·8	− 7·0	− 8·1	−13·2	− 4·8	−14·2	2·6
4	− 2·3	17·0	−20·9	5·0	0·1	19·9	3·3	−18·5	− 2·3	− 0·9	− 5·5	1·3	14·7	4·9	12·8	− 1·7	6·3	−12·7	− 4·0
5	4·3	−15·5	−10·7	0·7	− 0·2	− 8·8	28·9	19·7	2·2	0·2	0·2	11·5	− 7·7	10·0	4·2	5·3	− 6·1	5·7	− 9·2
6	−25·8	− 9·3	22·6	13·5	−16·3	− 6·8	− 2·0	− 7·3	− 2·2	8·9	− 1·7	−15·2	−12·5	1·3	− 7·3	− 3·7	5·4	11·2	9·2
7	3·9	19·1	3·9	24·6	5·9	3·4	− 6·3	20·8	− 0·4	− 7·5	− 0·3	3·3	3·2	− 1·9	6·9	− 6·8	15·6	0·9	14·8
8	−16·7	−18·6	− 0·2	3·1	1·5	8·1	4·8	−12·8	− 8·4	− 1·4	− 4·3	− 7·2	− 8·3	3·0	− 0·5	− 5·4	− 0·9	3·5	− 2·8
9	− 5·5	5·4	8·8	9·4	6·6	−13·5	− 3·6	7·7	8·4	− 9·1	− 5·0	4·8	7·9	− 4·8	2·9	8·9	− 5·4	4·9	− 2·5
10	− 0·1	−11·6	−13·8	3·5	10·3	10·7	1·2	− 0·8	− 6·6	6·9	12·0	7·0	− 0·3	0·7	− 1·9	− 2·1	0·5	− 0·9	− 4·1
11	−10·5	− 8·7	−19·9	3·9	8·1	− 9·8	− 0·9	4·6	4·2	2·0	− 5·4	4·9	−12·1	−14·0	−11·3	− 5·4	6·5	4·6	3·1
12	18·1	7·9	− 1·7	3·0	− 2·5	4·0	0·5	6·1	− 3·9	15·5	10·0	2·9	− 4·1	2·4	− 5·3	− 7·6	− 0·5	− 0·6	8·7
13	− 2·0	−16·9	− 0·5	11·8	4·1	− 4·3	−12·0	8·7	4·2	− 1·7	− 3·5	−13·0	− 4·7	1·6	0·1	3·8	− 1·3	6·5	0·4
14	− 1·3	8·8	4·9	− 5·1	−12·9	2·5	1·5	− 6·6	5·8	− 6·5	2·0	− 4·8	9·0	2·5	− 3·5	4·0	− 8·7	5·9	− 5·3
15	− 7·4	6·8	10·0	− 1·3	6·0	11·4	4·4	−13·8	1·2	8·1	− 8·3	− 3·5	− 1·4	3·2	− 4·3	4·1	1·5	2·2	0·5
16	−14·2	− 1·2	0·2	− 1·1	0·4	−13·6	1·2	5·0	10·1	− 1·2	−13·1	11·6	− 1·7	0·3	3·7	0·3	− 3·3	− 5·1	1·5
17	5·1	8·4	14·4	− 4·7	− 8·3	5·9	− 9·7	− 9·7	− 6·3	− 0·5	5·0	0·7	4·1	8·4	− 0·8	0·7	− 5·5	− 2·0	− 3·2
18	5·2	− 3·8	3·4	1·3	− 6·1	− 8·4	− 8·9	10·3	− 3·2	− 6·9	8·4	7·9	4·5	− 1·7	− 0·1	3·5	− 5·0	− 1·5	− 3·8

Table II. Fourier Coefficients for the Bouguer Gravity Anomalies. (in mgal.)

m \ n	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	118·0	−24·0	−38·7	13·9	10·4	8·6	−20·3	7·1	−1·1	11·5	−4·5	−0·8	−0·6	1·1	−1·1	2·7	−4·4	−3·0	2·1
1	6·7	−11·4	4·4	3·9	30·5	4·3	−6·9	−16·3	6·2	4·6	−2·2	−6·8	1·0	0·4	1·5	−3·7	−2·1	−5·1	5·1
2	−53·6	59·1	40·8	−28·4	−11·6	2·3	23·8	−15·9	1·9	−5·6	2·2	−7·1	4·2	−7·5	5·7	−3·3	1·8	−2·5	1·5
3	20·6	−6·1	12·6	7·6	−36·8	−11·4	5·1	−8·1	1·6	0·5	0·7	4·7	−3·0	2·6	−4·9	2·4	3·2	4·2	−2·4
4	−16·7	−23·4	42·2	−2·2	−18·9	5·9	11·7	−5·3	5·8	−0·0	−2·9	4·7	−3·6	2·9	−7·6	5·6	−3·5	4·9	−1·4
5	−1·3	13·1	−6·6	−12·6	8·0	22·8	−14·7	−1·3	0·7	2·4	0·1	−0·5	4·9	−9·7	2·8	−1·1	1·2	−2·9	2·6
6	2·6	−3·4	−16·8	0·2	−6·7	8·5	0·0	7·7	0·3	0·6	−7·7	1·9	−2·4	0·3	2·9	−0·6	5·7	−4·0	−0·7
7	−9·2	4·0	−6·9	−2·0	−0·0	1·6	6·4	0·2	4·3	−7·2	−3·7	−7·8	3·5	1·0	−1·2	8·3	−2·9	2·9	−3·7
8	2·8	1·2	−8·0	5·7	4·8	−3·7	−5·6	3·3	1·0	−3·3	4·4	−0·2	4·4	−0·1	−4·5	−2·9	0·0	1·4	−1·4
9	4·3	−1·9	−7·1	2·3	7·6	−6·4	2·0	−3·6	0·9	7·1	−6·5	1·5	−1·3	5·1	−0·2	−5·1	1·1	−2·0	2·0
10	−1·7	1·4	3·5	−0·6	0·9	−1·1	−9·6	0·1	2·7	−5·7	4·3	0·6	−5·1	6·9	−0·4	−1·3	0·4	1·4	2·5
11	−2·1	4·0	3·3	−9·8	−0·1	6·7	−12·3	2·4	0·1	−3·7	5·2	1·7	1·9	−3·3	2·3	0·8	−0·2	0·8	−2·0
12	1·7	2·0	7·9	−3·3	−0·6	−3·8	1·5	3·3	−1·5	0·9	−2·5	1·1	−1·1	−4·4	2·4	−1·8	−0·0	3·9	0·5
13	1·9	−1·3	0·3	−6·8	−2·3	−1·6	−1·7	−2·6	1·3	4·4	−3·2	3·4	−0·8	4·2	−0·2	0·7	−1·2	0·4	0·3
14	5·0	−1·1	−3·4	4·7	−0·2	−6·3	0·3	−1·5	−1·2	2·2	0·3	−0·7	2·8	0·0	−1·6	3·3	−3·0	2·4	−1·2
15	−1·5	−1·8	−2·5	1·3	−2·3	0·0	−1·6	1·4	0·0	−0·7	3·3	1·0	2·3	−4·2	−1·3	−0·4	−1·6	3·2	0·9
16	1·2	0·1	2·6	2·0	−1·7	−6·7	−0·9	2·8	0·6	−1·0	−3·4	1·5	2·0	0·6	0·0	1·5	2·8	−5·1	4·7
17	2·8	−0·5	−6·3	2·3	1·8	−3·3	2·7	3·8	−0·2	−3·8	−0·1	0·4	−1·8	1·0	0·3	−1·4	1·8	−4·5	−1·9
18	0·9	3·0	−4·7	0·1	0·7	1·5	−2·4	−2·3	3·8	−2·0	0·1	−1·7	1·1	−4·0	1·8	1·2	−1·7	1·6	0·4

depth $(-H')$ was regarded effectively as of $-0{\cdot}62H'$, since

$$\frac{\rho_2-\rho_1}{\rho_2}H'=\frac{2{\cdot}7-1{\cdot}0}{2{\cdot}7}H'=0{\cdot}62H'.$$

The Fourier coefficients H_{mn} and B_{mn}, which were found down to the order $m=18$ and $n=18$, are given in Tables I and II.

It was already shown that if we assume Airy isostasy, B_{mn} and the corresponding H_{mn} are connected by the relation

$$B_{mn}=-2\pi k^2\rho_2 H_{mn}\exp(-\sqrt{m^2+n^2}d)$$

where d is the thickness of the isostatic earth's crust. From this relation, we get

$$d=-\frac{1}{\sqrt{m^2+n^2}}\log\left(-\frac{B_{mn}}{2\pi k^2\rho_2 H_{mn}}\right)$$

whence d can be found for each pair of B_{mn} and H_{mn}. In order that the resulting value of d shall be reasonable, the following two conditions must be satisfied; (1) B_{mn} and the corresponding H_{mn} must differ in algebraic sign, and (2) $|2\pi k^2\rho_2 H_{mn}|$ must be greater than $|B_{mn}|$. Of the 361 pairs of H_{mn} and B_{mn} $(m\times n=19\times 19=361)$, 169 pairs fulfill the above two conditions. The weighted mean of d's, as determined from these 169 pairs of B_{mn} and the corresponding H_{mn}, worked out to

$$d=0{\cdot}0722 \text{ (radian)}.$$

Since 1400 km has been taken as π, this value of d corresponds to

$$\frac{1400}{\pi}\times 0{\cdot}0722=32{\cdot}2\text{ km}.$$

In this connection, it is interesting that from the study of the dispersion of the Rayleigh seismic waves across the Pacific, K. E. Bullen[3] recently obtained the value of 26 km as the thickness of the earth's crust under that ocean. Since the average of the effective depth of the whole area under study is 1 km, the thickness of the earth's crust corresponding to zero elevation is

$$32+1\times\frac{2{\cdot}7}{3{\cdot}0-2{\cdot}7}=41\text{ km}.$$

There are various combinations of m and n that result in equal

3) K. E. Bullen, *Monthly Notices Roy. Astro. Soc. Geophys. Suppl.*, 4 (1939), 579.

or nearly equal $\sqrt{m^2+n^2}$, which is the order of the Fourier coefficients. The whole 361 pairs of H_{mn} and B_{mn} may be grouped according to this order. In each of such groups, there are two kinds of pairs, (α) and (β). While in the α pairs, H_{mn} and B_{mn} differ in algebraic sign, in the β pairs, they do not. It was already shown that from the consideration of regional isostasy, the percentage $\frac{\alpha}{\alpha+\beta}$ is ex-

Table III.

$\sqrt{m^2+n^2}$	Total Number of Pairs	α Pairs	$\frac{\alpha}{\alpha+\beta}$	
0~ 1	1	1	100%	}75
1~ 2	3	2	67	
2~ 3	4	3	75	}86
3~ 4	3	3	100	
4~ 5	7	6	86	}80
5~ 6	8	6	75	
6~ 7	6	5	83	}60
7~ 8	9	4	44	
8~ 9	12	6	50	}58
9~10	12	8	67	
10~11	11	5	45	}52
11~12	14	8	57	
12~13	15	9	60	}63
13~14	15	10	67	
14~15	18	9	50	}58
15~16	18	12	67	
16~17	20	14	70	}60
17~18	20	10	50	
18~19	23	12	52	}55
19~20	17	10	59	
20~21	14	5	36	}56
21~22	18	13	72	
22~23	19	9	47	}50
23~24	13	7	54	
24~25	15	7	47	}44
25~26	17	7	41	
26~27	9	4	44	}41
27~28	8	3	38	
28~29	6	3	50	}30
29~30	4	0	0	
30~31	2	2	100	
Total	361	203	56	

pected to decrease from 100 down to 50 as the order $\sqrt{m^2+n^2}$ increases. Table III and Fig. 3 show this tendency very clearly.

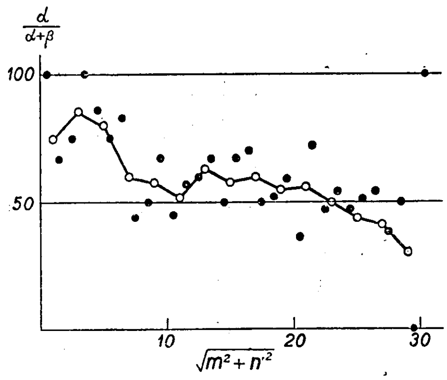

Fig. 3.

In Fig. 4, a small square defined by a combination of m and n is made black, if H_{mn} and B_{mn} corresponding to that m n are of opposite algebraic sign, while it is left blank if H_{mn} and B_{mn} are of the same sign. The abundance of the black squares for smaller m and n is noteworthy.

If, from Fig. 3, we regard that the percentage $\dfrac{\alpha}{\alpha+\beta}$ is 50 when $\sqrt{m^2+n^2}$ exceeds 25, this will correspond to

$$m=n=18.$$

Since 1400 km was taken as π in the present analysis, the wave-length of this harmonics is

$$1400\times 2\div 18=160\text{ km}.$$

The natural conclusion to be drawn from the foregoing results is that topographical features that are smaller than half this length, 80 km across, are supported by some mechanism other than isostasy; in other words the degree of regionality R is 80 km. The ratio of this regionality to the thickness of earth's crust is, in the present case,

$$80\div 32=2.5.$$

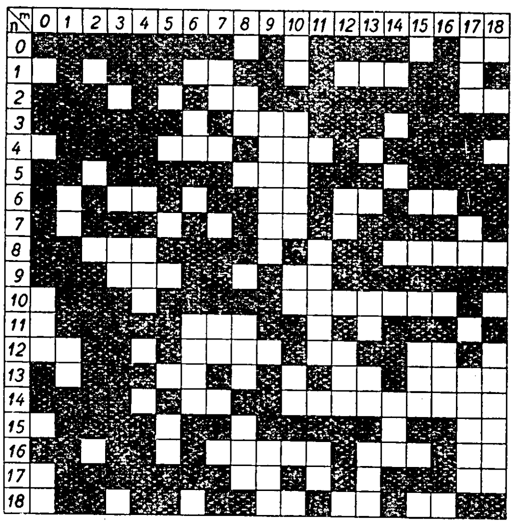

Fig. 4.

According to perfect Airy isostasy, the mass that is expressed by

$$-\rho_2\sum\sum H_{mn}\cos mx\cos ny$$

is distributed at a depth which is 32·2 km in the present case. The gravity due to this mass that is to be observed on the earth's sur-

Table IV. Fourier Coefficients for the Isostatic Anomalies. (in mgal.)

n \ m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	6·3	16·1	2·9	2·7	−6·4	−6·8	−17·9	2·4	−4·3	4·9	−4·9	1·2	7·9	−2·6	4·4	5·2	−3·2	−3·9	2·3
1	29·8	4·7	39·8	0·1	−13·7	−7·3	−11·4	−23·5	2·8	1·7	−9·2	−3·3	2·5	0·8	6·4	2·5	1·4	−5·6	4·8
2	−11·5	3·1	26·6	−29·6	1·3	5·7	8·1	−17·6	2·6	6·6	−2·3	−1·6	2·7	−3·8	4·6	0	−0·6	−3·1	3·0
3	−14·1	0	−23·9	4·1	−23·5	0·3	13·7	−3·3	2·7	7·0	3·5	2·2	2·3	−0·3	−8·1	−2·4	1·6	−0·3	−1·6
4	−18·4	−10·7	26·8	1·4	−18·8	19·0	13·8	−16·3	4·5	−0·5	−5·6	5·3	2·8	4·9	−2·7	5·0	−1·4	0·9	−2·6
5	1·6	2·6	−13·8	−12·1	7·9	17·5	2·1	9·6	1·9	2·5	0·2	4·6	1·7	−5·8	4·3	0·7	−0·8	−1·2	0
6	−13·3	−9·1	−3·1	8·2	−16·1	4·7	−1·1	4·0	−0·8	4·7	−8·4	−4·4	−7·3	0·8	0·4	−1·8	7·4	−0·8	1·8
7	−7·0	14·6	−4·8	11·2	3·1	3·3	3·3	10·1	4·1	−10·5	−3·8	−6·5	4·7	0·3	1·1	6·2	1·6	3·1	0·1
8	−5·6	−8·2	−8·1	7·2	5·5	0·1	−3·4	−2·3	−2·5	−3·9	2·7	−2·8	1·6	0·9	−4·7	−4·5	−0·3	2·3	−2·1
9	1·8	0·6	−3·1	6·5	10·5	−12·1	0·5	−0·5	4·1	3·7	−8·3	3·1	1·2	3·6	0·6	−2·7	−0·3	−0·8	1·4
10	−1·7	−3·4	−2·1	0·8	5·0	3·	−9·1	−0·2	0·4	−3·3	8·2	2·8	−5·2	7·1	−0·9	−1·8	0·5	1·2	−3·4
11	−6·0	0·8	−4·1	−8·4	2·8	3·3	−12·6	3·9	1·5	−3·1	3·6	3·1	−1·5	−7·0	−0·6	−0·5	1·3	1·8	−1·4
12	7·8	4·7	7·3	−2·3	−1·4	−2·5	1·7	5·2	−2·7	5·3	0·3	1·9	−2·1	−3·8	0·6	−4·1	−0·1	3·8	2·2
13	1·3	−6·4	1·1	−3·3	−1·1	−2·8	−5·1	−0·2	2·4	4·0	−4·1	0·2	−1·9	4·6	−0·2	1·5	−1·5	1·6	0·4
14	4·6	1·3	−2·1	3·3	−3·6	−5·6	0·7	−3·2	0·2	0·7	0·8	−1·8	4·7	0·5	−2·3	4·1	−4·6	3·4	−2·1
15	−3·3	−0·1	0	1·0	−0·9	2·7	−0·6	−1·8	0·3	1·1	1·6	0·3	2·0	−3·6	−2·1	0·3	−1·3	3·6	1·0
16	−2·0	−0·2	2·6	1·8	−1·6	−9·6	−0·6	3·8	2·6	−1·2	−5·9	3·7	1·7	0·7	0·6	1·5	2·3	−5·9	4·9
17	3·8	1·2	−3·4	1·4	0·1	−2·1	0·8	2·0	−1·4	−3·9	0·8	0·5	−1·1	2·3	0·2	−1·3	1·0	−4·8	−2·3
18	1·9	2·3	−4·1	0·3	−0·4	0	−4·0	−0·5	3·3	−3·1	1·4	−0·5	1·8	−4·2	1·8	1·7	−2·4	1·4	−0·1

Table V. Fourier Coefficients for the Undulation of the Isostatic Geoid. (in 10^{-3} radian.)

n \ m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0		16·1	1·5	0·9	− 1·6	− 1·4	− 3·0	0·3	− 0·5	0·5	− 0·5	0·1	0·7	− 0·2	0·3	0·4	− 0·2	− 0·2	0·1
1	21·3	2·7	17·8	0	− 3·2	− 1·4	− 1·9	− 3·3	0·3	0·2	− 0·9	− 0·3	0·2	0·6	0·5	0·2	0·1	− 0·3	0·3
2	− 4·1	1·0	7·8	− 7·2	0·3	1·0	1·2	− 2·3	0·3	0·7	− 0·2	− 0·1	0·2	− 0·3	0·3	0	0	− 0·2	0·2
3	− 3·4	0	− 5·1	0·8	− 4·1	0·5	1·9	− 0·4	0·3	0·7	0·3	0·2	0·2	− 0·2	− 0·6	− 0·2	0·1	0	− 0·1
4	− 3·3	− 1·9	4·5	0·2	− 2·7	2·5	1·7	− 1·8	0·5	0	− 0·5	0·4	0·2	0·3	− 0·2	0·3	− 0·1	0·1	− 0·1
5	0·2	0·4	− 1·9	− 0·2	1·0	2·0	0·2	1·0	0·2	0·2	0	0·4	0·1	− 0·4	0·3	0	0	− 0·1	0
6	− 1·6	− 1·1	− 0·4	0·9	− 1·7	0·5	− 0·1	0·4	− 0·1	0·4	− 0·6	− 0·3	− 0·5	0·1	0	− 0·1	0·4	0	0·1
7	− 0·7	1·5	− 0·5	1·1	0·3	0·3	0·3	0·8	0·3	− 0·8	− 0·3	− 0·4	0·3	0	0·1	0·3	0·1	0·2	0
8	− 0·5	− 0·7	− 0·7	0·6	0·5	0	− 0·3	− 0·2	− 0·2	− 0·3	0·2	− 0·2	0·1	0·1	− 0·3	− 0·2	0	0·1	− 0·1
9	0·1	0	− 0·2	0·5	0·8	− 0·9	0	0	0·3	0·2	− 0·5	0·2	0·1	0·2	0	− 0·1	0	0	0·1
10	− 0·1	− 0·2	− 0·1	0·1	0·3	0·2	− 0·6	0	0	− 0·2	0·5	0·2	− 0·3	0·4	− 0·1	− 0·1	0	0·1	− 0·1
11	− 0·4	0·1	− 0·3	− 0·5	0·2	0·2	− 0·8	0·2	0·1	− 0·2	0·2	0·2	− 0·1	− 0·3	0	0	0·1	0·1	− 0·1
12	0·5	0·3	0·4	− 0·1	− 0·1	− 0·1	0·1	0·3	− 0·1	0·3	0	0·1	− 0·1	− 0·2	0	− 0·2	0	0·2	0·1
13	0·1	− 0·4	0	− 0·2	− 0·1	− 0·1	− 0·3	0	0·1	0·2	− 0·2	0	− 0·1	0·2	0	0·1	− 0·1	0·1	0
14	0·2	0·1	− 0·1	0·2	− 0·2	− 0·3	0	− 0·2	0	0	0	− 0·1	0·2	0	− 0·1	0·2	− 0·2	0·1	− 0·1
15	− 0·2	0	0	0	0	0·1	0	− 0·1	0	0	0·1	0	0·1	− 0·1	− 0·1	0	0	0·1	0
16	− 0·1	0	0·1	0	0	− 0·4	0	0·1	0	0	− 0·1	0·1	0·1	0	0	0·1	0·1	− 0·2	0·2
17	0·2	0·1	− 0·1	0·1	0	− 0·1	0	0·1	− 0·1	− 0·2	0	0	0	0·1	0	0	0	− 0·2	− 0·1
18	0·1	0·1	− 0·2	0	0	0	− 0·2	0	0·1	− 0·1	0·1	0	0·1	− 0·1	0·1	0·1	− 0·1	0	0

face is

$$-2\pi k^2\rho_2\sum\sum H_{mn}\exp(-\sqrt{m^2+n^2}\,d)\cos mx\cos ny.$$

Since, on the other hand, the gravity anomaly actually observed is expressed by

$$\sum\sum B_{mn}\cos mx\cos ny,$$

the isostatic anomaly is given by

$$\sum\sum\{B_{mn}+2\pi k^2\rho_2 H_{mn}\exp(-\sqrt{m^2+n^2}d)\}\cos mx\cos ny.$$

Table IV gives the coefficients for this last series. The values of this series at every 10° of x and y in the area under study were then calculated, utilizing the B_{mn}, H_{mn} and d that were already found. The distribution of the isostatic anomalies obtained in this way agreed very well with those obtained by Vening Meinesz on the assumption of 25 km Airy regional isostasy.

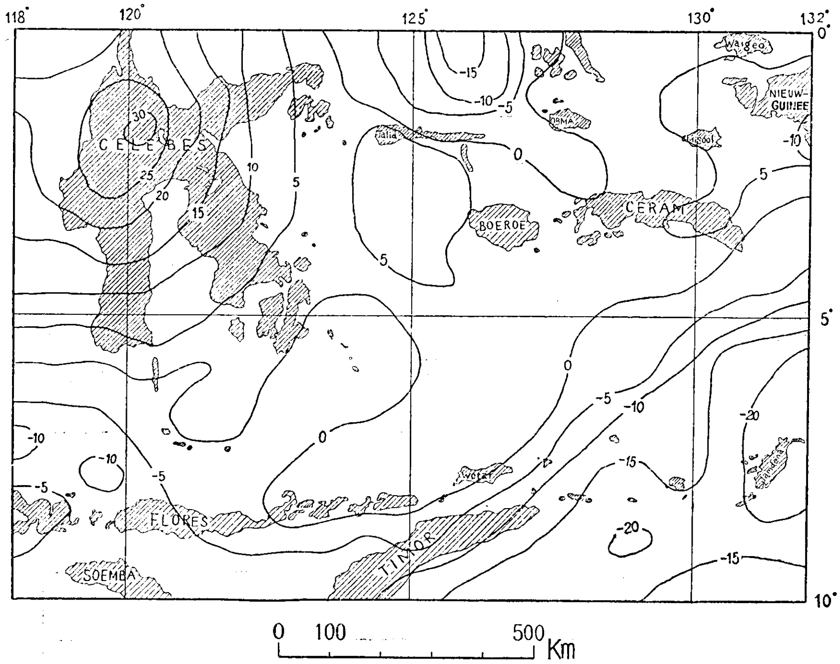

Fig. 5. Undulation of the Isostatic Geoid. (m.)

The undulation of the isostatic geoid was already shown to be given by

$$\sum\sum\frac{1}{\sqrt{m^2+n^2}}\Big\{B_{mn}+2\pi k^2\rho_2 H_{mn}\exp(-\sqrt{m^2+n^2}d)\Big\}\cos mx\cos ny.$$

Table V gives the value of the coefficients of this series. The value of this series at every 10° of x and y were also calculated, Fig. 5 showing the contour lines of the isostatic geoid as expressed in m.

It will be seen that along the zone of large negative gravity anomalies, the isostatic geoid is depressed by more than 20 m below the average earth's surface, which was taken as a geometrical plane in the present analysis.

Although the present study is scarcely more than a mere addition of the example of applications of Tsuboi's method, owing to the accumulation of similar studies, several interesting geophysical facts were found. For instance, it is likely that the regionality of isostasy R is always approximately from 2 to 3 times the thickness of the isostatic earth's crust d, irrespective of the thickness itself, as Table VI shows. This noteworthy behavior of the earth's crust is likely to be connected with the empirical fact that there is an upper limit to the energy of an earthquake. An hypothesis regarding this point has been proposed in another paper[4].

Table VI.

Place	d	R	R/d
Japan	50 km	85	1·9
U.S.A.	61	145	2·4
Dutch East Indies (Western Half)	36	60	1·7
Dutch East Indies (Eastern Half)	32	80	2·5

Miss T. Ayabe, to whom we express our thanks, has helped us much in the numerical computations involved in the present study. A part of the expense necessary for this study was defrayed from the Funds for Scientific Research of the Department of Education.

4) C. TSUBOI, *Proc. Amp. Acad. Tokyo*, **16** (1940), 449.

4. 重力異常と地下構造との關係 (VI.)

地震研究所 {坪井忠二
山口生知}

蘭領東インド諸島の東半分に於ける重力異常を材料とし，二重 Fourier 級數を利用して此の地域の地下構造を論じた．其の結果を要約すれば次の通りである．

1. Airy 均衡地殼の厚さは 32 km である．
2. 地方的均衡の極限は 80 km である．
3. 均衡ジオイドは最大 20 m も凹んで居る．
4. 一般に地方的均衡の極限は均衡地殼の厚さの 2〜3 倍であるらしい．