26. *The Most Suitable Formula for Gravity Values in Tyosen, Japan.*

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The most suitable formula for the gravity values in Japan[1] excluding Tyōsen, that in 1933 C. Tsuboi[2] determined, was however, revised in 1935.[3] From the coefficient to $\sin^2\varphi$ in Tsuboi's formula, it was found that the value of the "flatness", deduced as $\varepsilon=\frac{1}{322}$, was smaller than those given by Helmert, Hayford, etc. This particular form of the earth is believed to be due to local anomalies in the mode of distribution of gravity values in Japan.

In these circumstances the writer decided to study the form of the geoid in other localities near Japan, for which purpose the gravity values in Tyōsen (Korea) were investigated.

In order to determine the formula for the gravity distribution in Tyōsen, the equation

$$\gamma=g_e(1+\beta\sin^2\varphi-0{\cdot}000007\sin^2 2\varphi) \qquad (1)$$

was used. In Tsuboi's case, the formula used has the form

$$\gamma=g_e(1+\beta\sin^2\varphi).$$

For convenience in comparing the result obtained from the data in Tyōsen with those in Japan, the formula for normal gravity in Japan was redetermined with the equation (1).

The constants in the redetermined formula for gravity distribution in Japan were almost the same as those given by C. Tsuboi. The gravity values were measured at 122 stations in Japan[4] and at 23 stations in Tyōsen.[5] The reduced values of gravity g_0 and g_0'' at these stations were used as data for the present calculation.

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* Comm. by N. Miyabe.

1) By "Japan", in this paper, is meant that region including Honsyū, Sikoku, Kyūsū, and Hokkaido, i.e. the main islands of Japan.

2) C. TSUBOI, *Bull. Earthq. Res. Inst.*, **11** (1934), 632.

3) C. TSUBOI, *Bull. Earthq. Res. Inst.*, **13** (1935), 555.

4), 5) Data from "*Rikwa Nenpyô*", (1930), 311.

From the coefficients of the terms of $\sin^2\varphi$ and $\sin^4\varphi$ in the above expressions, the flatness was determined for both cases, Japan and Tyōsen, separately, by means of the formula[6]

$$\varepsilon=\frac{5}{2}\frac{\omega^2 a_e}{g_e}-\beta-\varepsilon\left(\varepsilon+\frac{1}{2}\frac{\omega^2 a_e}{g_e}\right)+\frac{2}{21}(7\varepsilon^2-4\varepsilon\beta+0{\cdot}000028)+\cdots\cdots. \qquad (2)$$

The flatness thus determined is, however, that of an imaginary earth, the gravity values of whose latitudes are the same for corresponding latitudes in Japan or Tyōsen.

In calculating the flatness, since the value of the equatorial radius a_e as worked out by Bessel and Kleins was used, the value of the flatness from different values of the equatorial radii were almost the same.

The results of the calculations are summarized in Table I subjoined, the expressions for the gravity distribution in Japan and in Tyōsen being shown graphically in Fig. 1.

Table I.

	g_e	β	$1/\varepsilon$	$g-\gamma$ max.	min.	mean.	$\Sigma\|g-\gamma\|$
Helmert (1901)	978·030	0·005302	298·3				
Tsuboi (1933) (Bouguer)	977·981	0·005562	322	+0·154,	−0·106,	−0·008	4·338
Tsuboi (1935) (Free air)	977·998±0·019	0·005538±0·000058	319·5±5·4	+0·161,	−0·111,	+0·035	
Japan Bouguer	977·991±0·028	0·005549±0·000078	Bessel; Kleins 321·8, 1·5 ±8·1	+0·155,	−0·105,	+0·006	5·324
Japan Fr. air	977·998±0·038	0·005555±0·000078	322·4, 2·2 ±8·1	+0·161,	−0·113,	+0·012	4·250
Tyōsen Bouguer	978·242±0·054	0·004772±0·000140	257·8, 7·7 ±9·3	+0·038,	−0·055,	+0·001	0·481
Tyōsen Fr. air	978·131±0·032	0·005107±0·000082	282·0, 1·9 ±6·5	+0·044,	−0·037,	±0·000	0·236

The expression adopted of the Normal gravity for Tyōsen, is—

$$\gamma=978{\cdot}131(1+0{\cdot}005107\sin^2\varphi-0{\cdot}000007\sin^2 2\varphi).$$

Thus, as was expected, the flatness calculated from the data of gravity values in Japan approaches very closely the value already worked out by C. TSUBOI, whereas the flatness from gravity values in

6) F. R. HELMERT, "*Theorien der Höheren Geodäsie*", Bd. II, (1884), S. 83.

7) F. R. HELMERT, "*Theorien der Höheren Geodäsie*", Bd. I, (1880), S. 18, 38. Bd. II, (1884), S. 84.

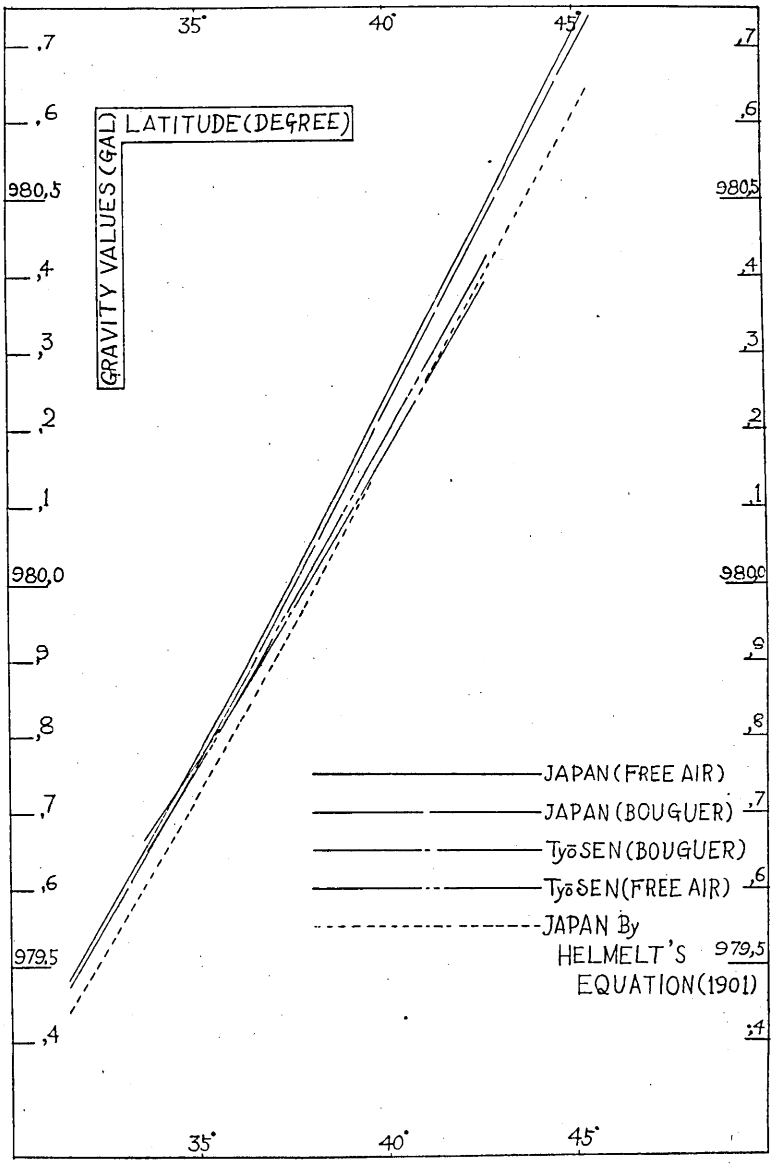

Fig. 1. Equations of normal gravity in Tyōsen and in Japan.

Tyōsen is larger, i. e. the value of $1/\varepsilon$ is about 5% smaller than those given by Helmert and Hayford. Such abnormal values of flatness may be regarded as representing the local anomalies in the mode of distribution of gravity in the neighbourhood of Japan and Tyōsen.

From the foregoing results, the following points are noticed:

(1) The difference in the inclination of the curves in Fig. 1, i. e. the coefficients of the term of $\sin^2\varphi$, deduced from the data of g_0

and g''_0 in Japan is very small, whereas the difference deduced from the data in Tyōsen is clearly larger. This may not be due merely to insufficient Tyōsen data.

(2) The lower end of the curve, showing the gravity distribution in Tyōsen, i. e. in the southern part of Tyōsen, coincides with the curve showing the gravity distribution in Japan, while the upper part of the curve coincides with Helmert's curve.

This latter fact may be connected either with the distribution of gravitational anomalies, or with the subterranean distribution of excessive or defective mass.

The gravitational anomalies, i. e. the Bouguer anomalies, in Tyōsen are in negative correlation with the heights, as shown in Fig. 2.

The approximate linear relation between $\Delta g''_0$ and the height H is expressed by $\Delta g''_0 = -KH$, where H is given in c. g. s. units. The coefficient K amounts to 1×10^{-6}, approximately. From this correlation, it may be said that the topographical irregularities in Tyōsen are as a whole compensated isostatically. This value of coefficient K approximately equals that expected from mass distribution when the crust is in isostatic equilibrium.[8]

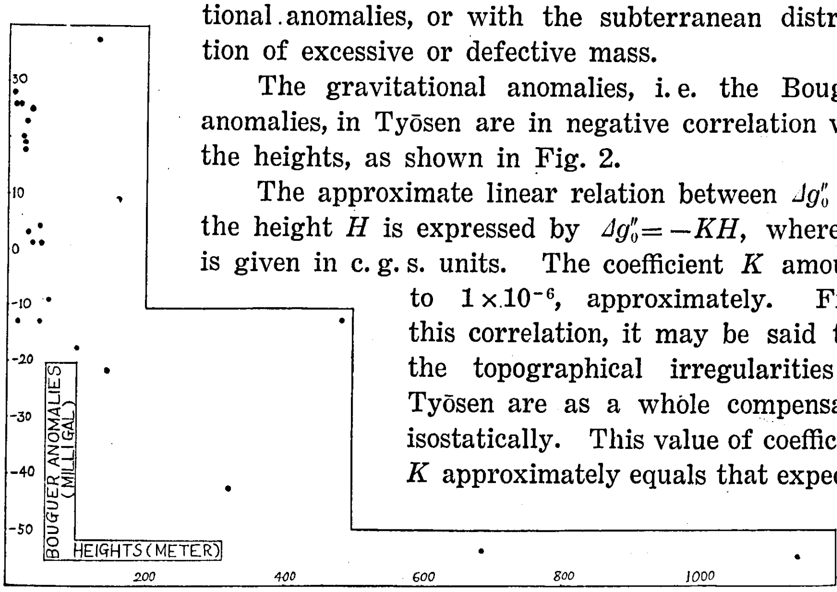

Fig. 2. Relation between the Bouguer anomalies and the topographic heights in Tyōsen.

8) When sial crust of thickness h, resting on the sima layer, is in isostatic equilibrium, the height of the surface above sea level being H, we get

$$h=\left(1-\frac{\rho}{\rho'-\rho}\right)H,$$

where ρ and ρ' are respectively the densities of the sial and sima layers.

Moreover, the gravity anomaly $\Delta g''_0$ due to defective or excessive density $\Delta\rho$ in the sial crust of thickness h is given by

$$\Delta g''_0=-2\pi k^2\Delta\rho h=-2\pi k^2\Delta\rho\left(1+\frac{\rho}{\rho'-\rho}\right)H.$$

Whence

$$K=2\pi k^2\Delta\rho\left(1+\frac{\rho}{\rho'-\rho}\right).$$

Evaluating constants, i. e. $2\pi=6{\cdot}28$ $k^2=6{\cdot}65\times10^{-8}$ c. g. s.

$\Delta\rho=0{\cdot}3$ $\rho=2{\cdot}7$ $\rho'=3{\cdot}0$,

we have $K=1{\cdot}2\times10^{-6}$ (c. g. s.)

The geographical distribution of $\varDelta g_0''$, the Bouguer anomalies, in Tyōsen is shown in Fig. 3. The negative values of $\varDelta g_0''$ are, as shown,

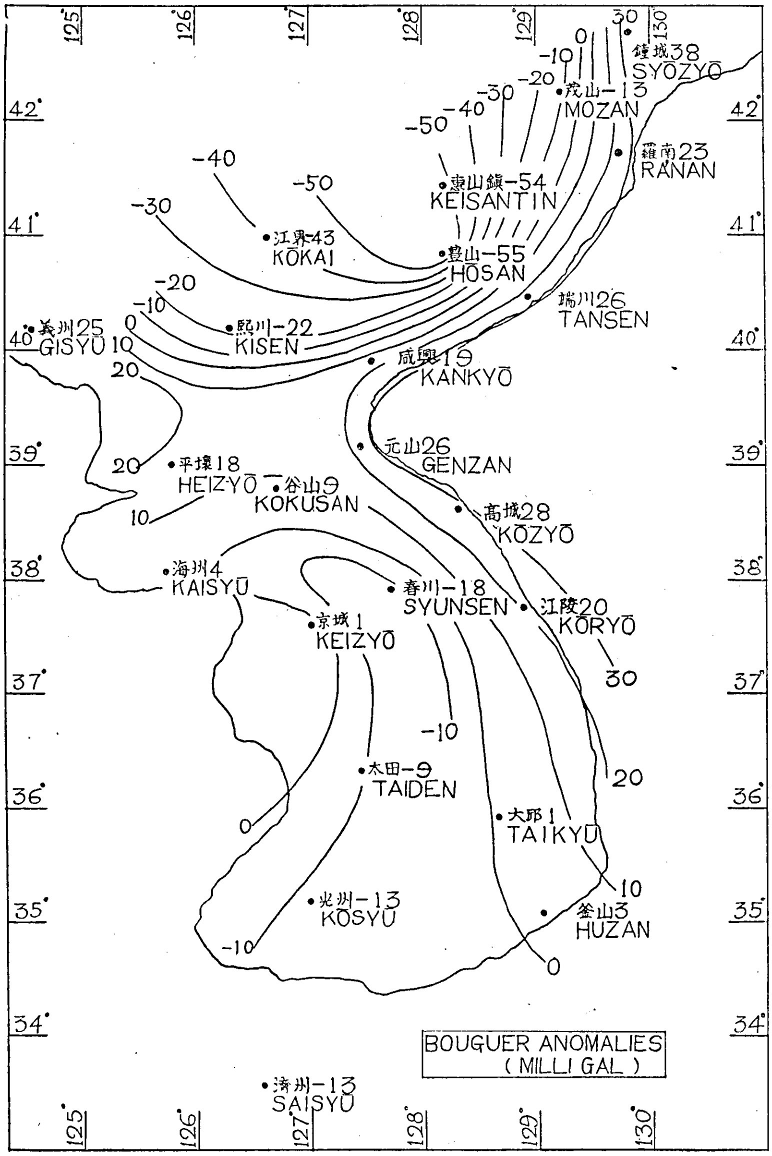

Fig. 3. Distribution of $\varDelta g_0''$ in Tyōsen.

being larger in the northern part, where the surface of the earth is generally higher than the southern regions.

This may be a cause for the smallness of the value of $1/\varepsilon$ calculated above. The subject will be discussed more fully in due course.

In conclusion, the writer wishes to express his cordial thanks to Dr. Naomi Miyabe for various valuable suggestions.

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26. 朝鮮及び日本の重力分布に適合する式

陸地測量部　早　川　　正　巳

朝鮮に於ける重力分布に最も適合する式として

$$\gamma=\begin{cases} 978{\cdot}242(1+0{\cdot}004772\sin^2\varphi-0\;000007\sin^2\varphi) \\ \pm0{\cdot}054 \quad \pm0{\cdot}000140 \\ \\ 976{\cdot}131(1+0{\cdot}005107\sin^2\varphi-0{\cdot}000007\sin^2\varphi) \\ \pm0{\cdot}032 \quad \pm0{\cdot}000082 \end{cases}$$

を得た．この様な重力分布を持つ地球の扁平率は $\frac{1}{258}$ (Bouguer anomalies を用ひて定めた場合)，又は $\frac{1}{282}$ (Free air anomalies を用ひて定めた場合) となる．

斯様に扁平率の値が大きくなる理由は朝鮮では isostatic equilibrium が比較的完全であり．且，北部が高峻な地帯であると云ふ事によるものの様である．詳細の事に關しては，地下構造を推定した後に更に論じたいと思ふ．
