23. Deformation of the Earth's Crust in the Iwate and Miyagi prefectures.

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1. In order to study the deformation of the earth's crust in the regions believed to have been considerably disturbed by the Sanriku earthquake of March 3, 1933, with which the great tunami was associated, the horizontal displacements of triangulation points in the prefectures of Iwate and Miyagi and the vertical displacements of the bench-marks along the level lines Tokyo-Miyako, Kamaisi-Kurosawaziri-Akita and Isinomaki-Ayukawa were measured the results of which were recently published[1].

This paper is an attempt to study modes of deformation of the earth's crust by means of the data of horizontal and vertical displacements of triangulation points and bench-marks just referred to.

2. The triangulation points in the region under consideration, the horizontal displacements of which were measured, are 10 primary triangulation points and 26 secondary triangulation points, the latter being mostly near the Pacific coast.

The horizontal displacements of the primary triangulation points occurred in the time interval of these 39~33 years, or from 1890~1900 to 1933, which differs from that in which the displacements of the secondary triangulation points occurred, that is, 36~24 years, or from 1897~1909 to 1933.

The horizontal deformation, Δ etc., are therefore calculated with reference to the primary triangulation points, being separated from those calculated with reference to the secondary triangulation points.

The quantities that represent the horizontal deformation of the earth's crust are

$$\Delta=\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y},$$

1) Rikuti-Sokuryôbu (Military Land Survey), "*Report of Revision of Triangulation and Levellings in the Sanriku Districts*", (Tokyo, 1934).

$$2\zeta=\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y},$$

$$2S=\frac{\partial v}{\partial x}+\frac{\partial u}{\partial y},$$

$$\gamma_{\frac{1}{2}}=\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)\pm\sqrt{\left(\frac{\partial v}{\partial x}+\frac{\partial u}{\partial y}\right)^2+\left(\frac{\partial u}{\partial x}-\frac{\partial v}{\partial y}\right)^2},$$

$$\tan\theta_1=\frac{\gamma_1-2\dfrac{\partial u}{\partial x}}{\dfrac{\partial v}{\partial x}+\dfrac{\partial u}{\partial y}},$$

$$S_m=\frac{1}{2}(\gamma_1-\gamma_2),$$

where u, v are x- and y-components of horizontal displacement, and Δ, ζ, S, γ_1, γ_2, S_m are divergence, rotation, shear, principal axes of strain, and maximum shear respectively.

These quantities are calculated as before[2] on the assumption that in the area limited by a triangle, the three vertices of which are the triangulation points, the deformation is uniform and continuous. Since, in the present case, no conspicuous faults appeared in association with the earthquake, this assumption might be justified to a certain degree; whereas, as in the case of the Kwantô and the Tango earthquakes, etc.[3], in which discontinuous movements along the faults were observed, the assumption might not be admissible.

The geographical distribution of the triangulation points and the level lines in the region under consideration are shown in Fig. 1. The triangulation points forming triangles and the amounts of the horizontal deformations are given in Tables I a, I b.

In the amounts of the horizontal deformations given in Tables I a, I b, we notice that:

(i) The horizontal deformations calculated for the triangles formed by primary triangulation points are generally smaller than those formed by the secondary triangulation points.

(ii) The horizontal deformation in the region are generally smaller than those in other regions where the earth's crust was disturbed by acute movements associated with destructive earthquakes. This point is discussed later.

2) T. Terada and N. Miyabe, *Bull. Earthq. Res. Inst.*, **7** (1929), 223.
3) C. Tsuboi, *Jap. Journ. Astr. Geophys.*, **9** (1933), 95.

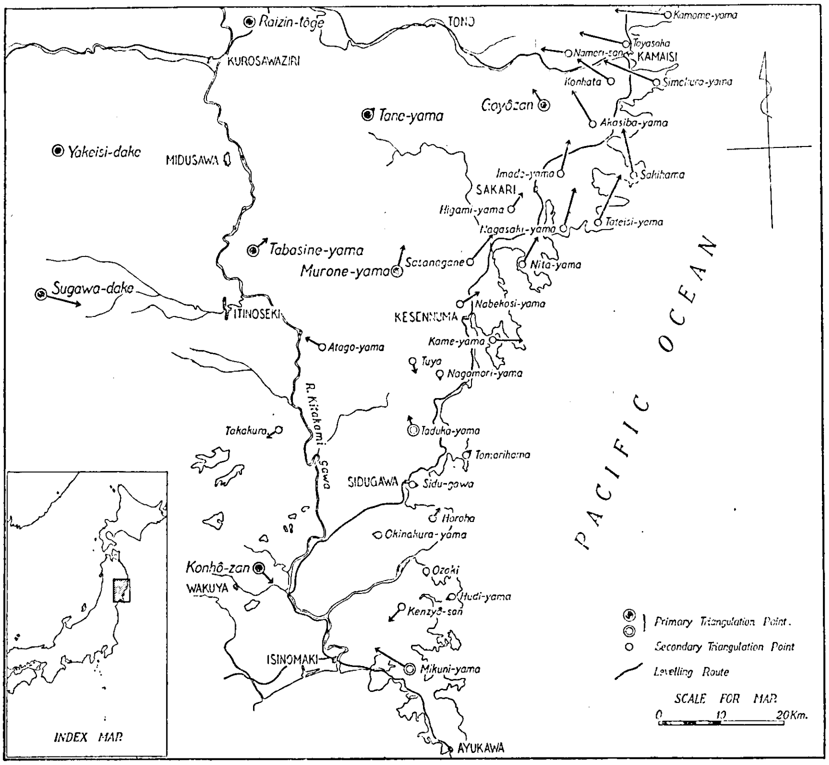

Fig. 1. Distribution of triangulation points and level lines. (Arrows show the horizontal displacements of the triangulation points.)

Table I a.

Δ etc. of triangles formed by primary triangulation points, given in 10^{-5}

Triangulation points	Δ	2ζ	S_m	γ_1	γ_2	θ_1
Tadukayama, Konhôzan, Mikuniyama,	−1.41	0·39	2·12	0·72	−3·53	57°07′
Tabasineyama, Sugawadake, Konhôzan,	−0.15	0·49	1·19	1·04	−1·33	75°21′
Tadukayama, Sugawadake, Konhôzan,	−0.12	0·51	1·22	1·10	−1·33	59°31′
Tadukayama, Tabasineyama, Konhôzan,	−0.13	0·55	1·20	1·06	−1·33	14°01′
Tabasineyama, Tadukayama, Sugawadake,	−0.16	0·64	1·06	0·90	−1·22	77°51′
Muroneyama, Tadukayama, Tabosineyama,	0.18	0·22	1·09	1·28	−0·91	62°55′
Goyôzan, Tadukayama, Muroneyama,	−0.62	−0·89	1·32	0·37	−2·27	−81°42′
Taneyama, Muroneyama, Tabasineyama,	−0.98	0·29	0·57	−0·41	−1·55	25°11′
Tabasineyama, Yakeisidake, Sugawadake,	0.01	1·94	1·09	1·10	−1·08	−65°01′

(to be continued.)

Table I a. *(continued.)*

Triangulation Points	Δ	2ζ	S_m	γ_1	γ_2	θ_1
Goyôzan, Taneyama, Muroneyama,	−1.57	0·64	0·45	−1·12	−2·03	78°00′
Raizintôge, Tabasineyama, Yakeisidake,	−0.18	−0·73	0·76	0·57	−0·94	−88°41′
Raizintôge, Taneyama, Tabasineyama,	−0.27	0·29	0·51	0·24	0·77	−26°26′
Raizintôge, Goyôzan, Taneyama,	−0.32	0·74	0·22	−0·10	−0·54	−66°11′

Table I b.

Δ etc. of triangles formd by secondary triangulation points, given in 10^{-5}

Triangulation Points	Δ	2ζ	S_m	γ_1	γ_2	θ_1
Kenzyôzan, Mikuniyama, Hudiyama,	−2.36	−0·14	5·01	2·64	−7·37	22°44′
Konhô-zan, Mikuniyama, Kenzyôzan,	2.83	−0·70	4·65	7·48	−1·82	72°43′
Okinakura-yama, Konhôzan, Kenzyôzan,	0.34	0·14	2·27	2·60	−1·93	81°41′
Tadukayama, Okinakurayama, Sidukawa,	4.34	−1·67	3·56	7·90	0·79	−35°48′
Tadukayama, Sidukawa, Tomarihama,	2.02	0·67	1·21	3·23	0·82	−69°34′
Takakura, Konhôzan, Okinakurayama,	−0.50	1·57	0·83	0·33	−1·33	−81°08′
Nagamoriyama, Tomarihama, Kameyama,	3.09	2·24	1·92	5·01	1·17	21°54′
Tuya, Tadukayama, Nagamoriyama,	−2.48	−0·18	1·88	−0·61	−4·36	9°09′
Ozaki, Kenzyôzan, Hudiyama,	1.51	−0·44	2·61	4·12	−1·10	48°00′
Okinakurayama, Kenzyôzan, Ozaki,	1.09	−1·70	0·77	1·86	0·33	−68°30′
Horoha, Ozaki, Hudiyama,	1.16	0·48	2·58	3·74	−1·42	58°23′
Horoha, Okinakurayama, Ozaki,	2.57	−0·13	1·24	3·81	1·33	46°09′
Sidukawa, Okinakurayama, Horoha,	0·31	1·10	2·86	3·17	−2·55	14°12′
Tomarihama, Sidukawa, Horoha,	−0.70	1·69	1·74	1·07	−2·44	13°23′
Sasanagane, Nabekosiyama, Nitayama,	1.14	−0·62	2·74	3·88	−1·61	79°40′
Muroneyama, Atagoyama, Tuya,	3.47	−1·42	0·99	4·46	2·48	−76°37′
Muroneyama, Nabekosiyama, Sasanagane,	3.06	−0·37	0·81	3·87	2·24	28°43′
Nitayama, Nabekosiyama, Kameyama,	2.34	1·29	1·79	4·13	0·55	−73°10′
Nabekosiyama, Tuya, Kameyama,	3.86	0·03	0·47	4·33	3·39	68°12′
Takakura, Okinakurayama, Tadukayama,	0.74	0·85	0·89	1·64	−0·15	42°26′
Muroneyama, Tuya, Nabekosi-yama,	3.54	−0·38	1·19	4·73	2·35	75°33′

(to be continued.)

Table I b. (*continued.*)

Triangulation Points	Δ	2ζ	S_m	γ_1	γ_2	θ_1
Atagoyama, Takakura, Tadukayama,	1.07	1·43	0·49	1·56	0·58	60°11′
Atagoyama, Takakura, Tuya,	−0.84	−2·13	3·64	2·80	4·49	−11°09′
Tuya, Nagamoriyama, Kameyama,	0.36	−2·36	4·60	4·96	−4·24	32°40′
Nagamoriyama, Tadukayama, Tomarihama,	−0.41	−1·28	2·69	2·28	−3·10	−19°45′
Goyôzan, Imadeyama, Akasibayama,	−2.43	3·11	1·08	−1·35	−3·51	−44°26′
Imadeyama, Nagasakiyama, Tateisiyama,	0.84	1·26	2·32	3·16	−1·48	7°21′
Goyôzan, Muroneyama, Higamiyama,	1.32	1·34	2·10	3·41	−0·78	−34°15′
Sitakurayama, Akasibayama, Sakihama,	−2.60	2·04	1·70	−0·90	− 4·30	−47°39′
Akasibayama, Imadeyama, Sakihama,	−2.19	2·91	1·36	−0·83	− 3·55	−64°48′
Imadeyama, Higamiyama, Nagasakiyama,	−0.85	2·38	1·79	0·94	− 2·64	35°43′
Imadeyama, Tateisiyama, Sakihama,	−2.27	3·49	1·84	−0·43	− 4·11	−58°19′
Higamiyama, Nitayama, Nagasakiyama,	−1.65	2·42	2·17	0·52	− 3·82	−38°27′
Higamiyama, Sasanagane. Nitayama,	−1.88	0 44	0·59	−1·29	− 2·47	−30°58′
Higamigama, Muroneyama, Sasanagane,	0.08	2·50	3·40	3·48	− 3·32	−20°07′
Goyôzan, Higamiyama, Imadeyama,	−0.47	3·49	1·00	0·53	− 1·46	16°14′
Namerisan, Toyasaka, Konhata,	−3.27	2·10	0·56	−2·72	− 3·83	47°28′
Namerisan, Goyôzan, Konhata,	−3.08	1·87	0·49	−2·59	− 3·56	− 6°20′
Konhata, Goyôzan, Akasibayama,	0.30	1·47	2·20	2·49	− 1·90	−87°01′
Konhata, Akasibayama, Sitakurayama,	−6.57	−0·45	4·09	−2·49	−10·66	−12°38′
Toyasaka, Konhata, Sitakurayama,	−3.58	1·18	0·84	−2·74	4·42	−61°34′
Kamomeyama, Toyasaka, Sitakurayama,	−2.33	0·28	0·80	−1·53	− 3·13	9°59′
Kamomeyama, Toyasaka, Konhata,	−3.23	1·43	1·09	−2·14	− 4·32	−34°55′

3. The geographical distribution of Δ, 2ζ, S_m, γ_1, γ_2, calculated by means of the horizontal displacements of the primary triangulation points are shown in Figs. 2∼5, while those by means of the data of the secondary triangulation points are shown in Figs. 6∼9.

In the modes of horizontal deformation in this region suggested by the geographical distribution of Δ, etc. (see Figs. 2∼9), we notice the following points:

(i) Although the divergences Δ's in the triangles formed by the primary triangulation points are on the whole negative, in those formed by the secondary triangulation points, the signs are positive in several regions and negative in others. In the latter, we can distinguish regions in which the signs of Δ alternate, being positive

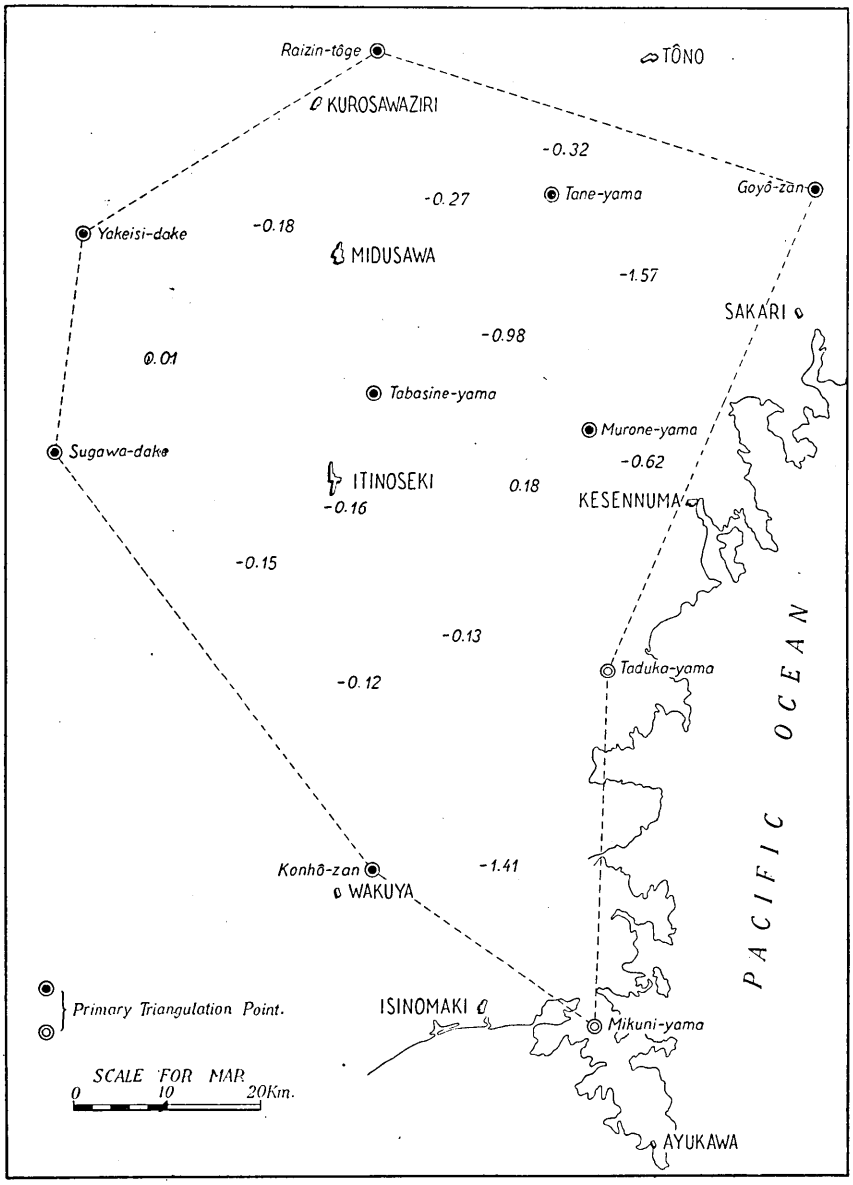

Fig. 2. Distribution of Δ of triangles formed by primary triangulation points. (Numerical figures designate amounts of Δ in 10^{-5}).

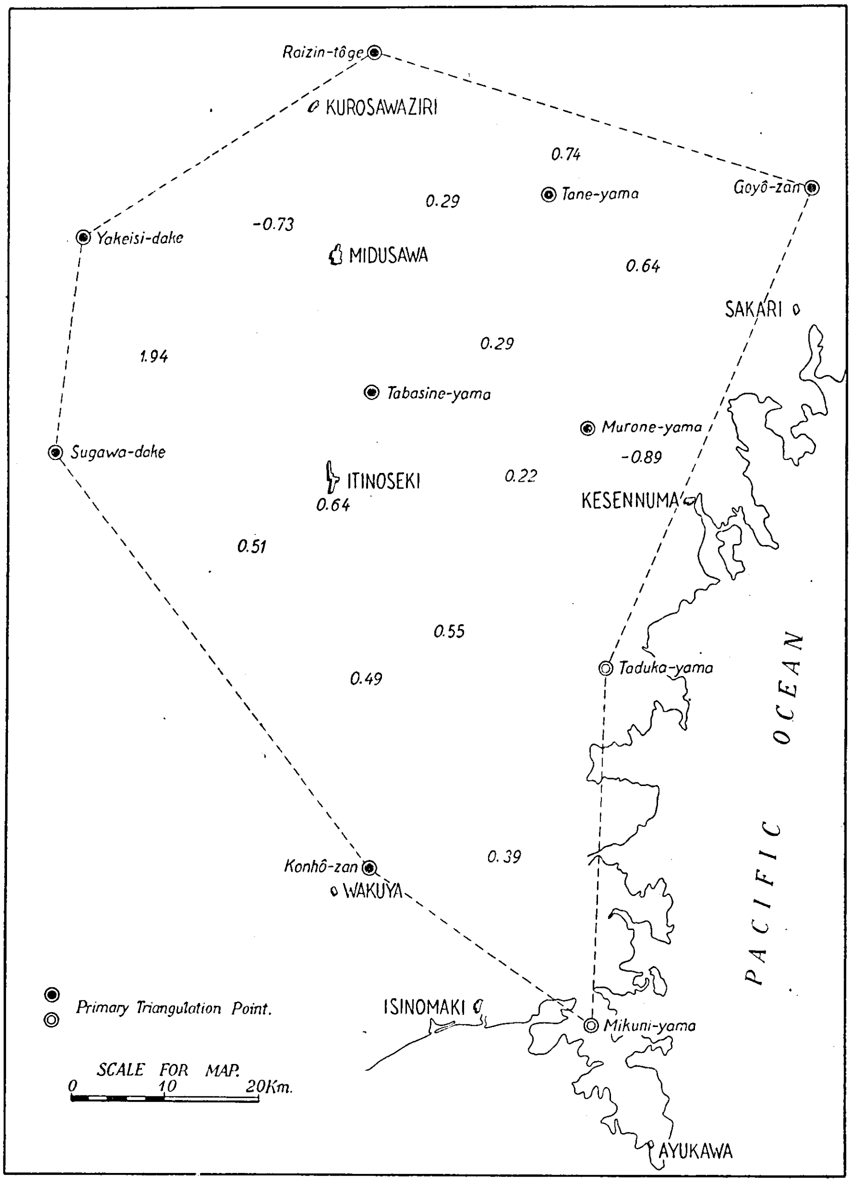

Fig. 3. Distribution of 2ζ of triangles formed by primary triangulation points. (Numerical figures designate amounts of 2ζ in 10^{-5}).

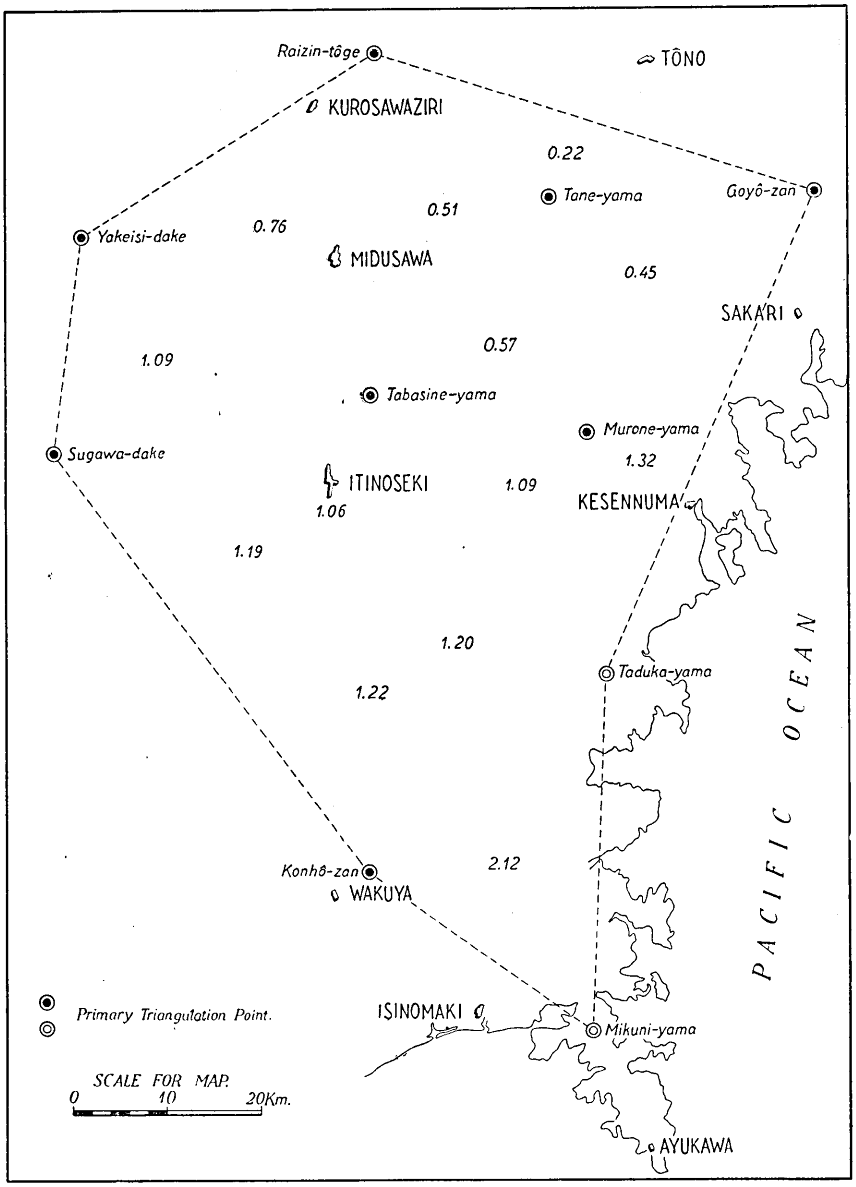

Fig. 4. Distribution of S_m of triangles formed by primary triangulation points. (Numerical figures designate amounts of S_m in 10^{-5}).

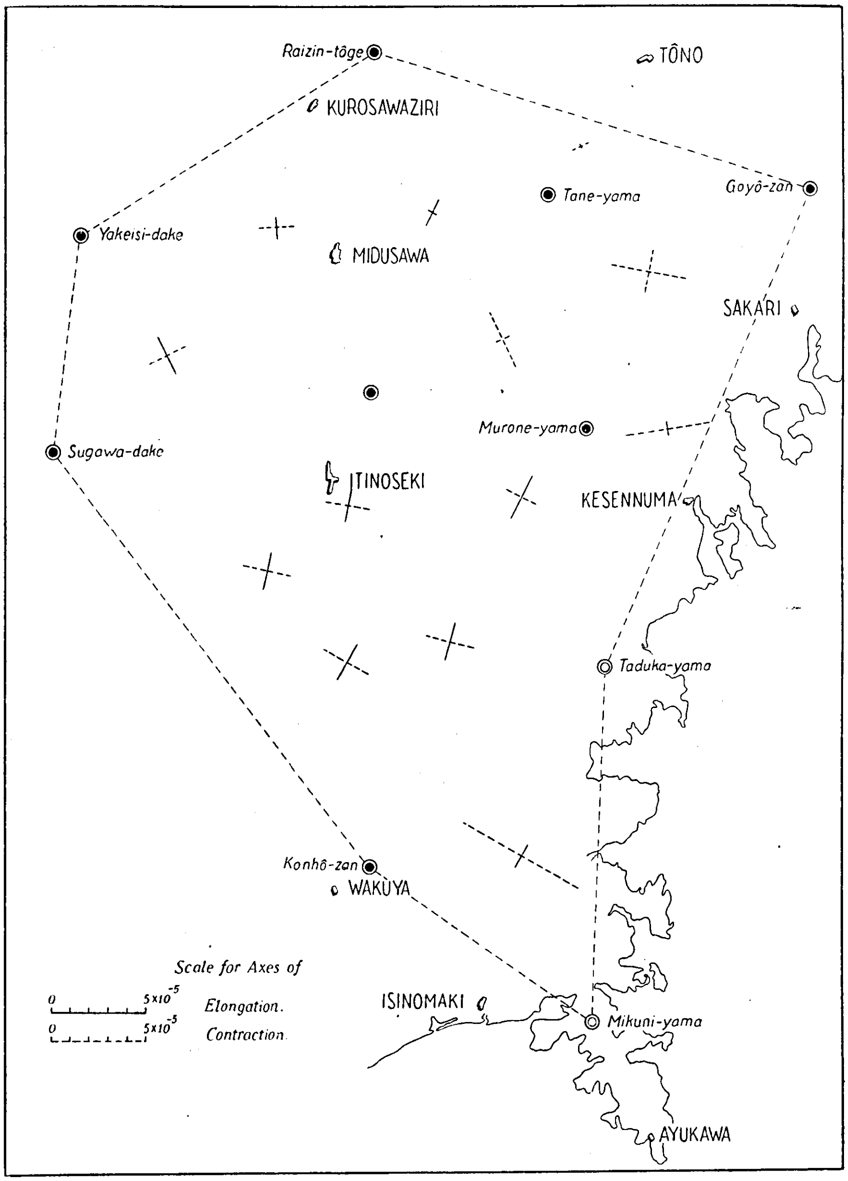

Fig. 5. Distribution of principal axes of strain in triangles formed by primary triangulation points.

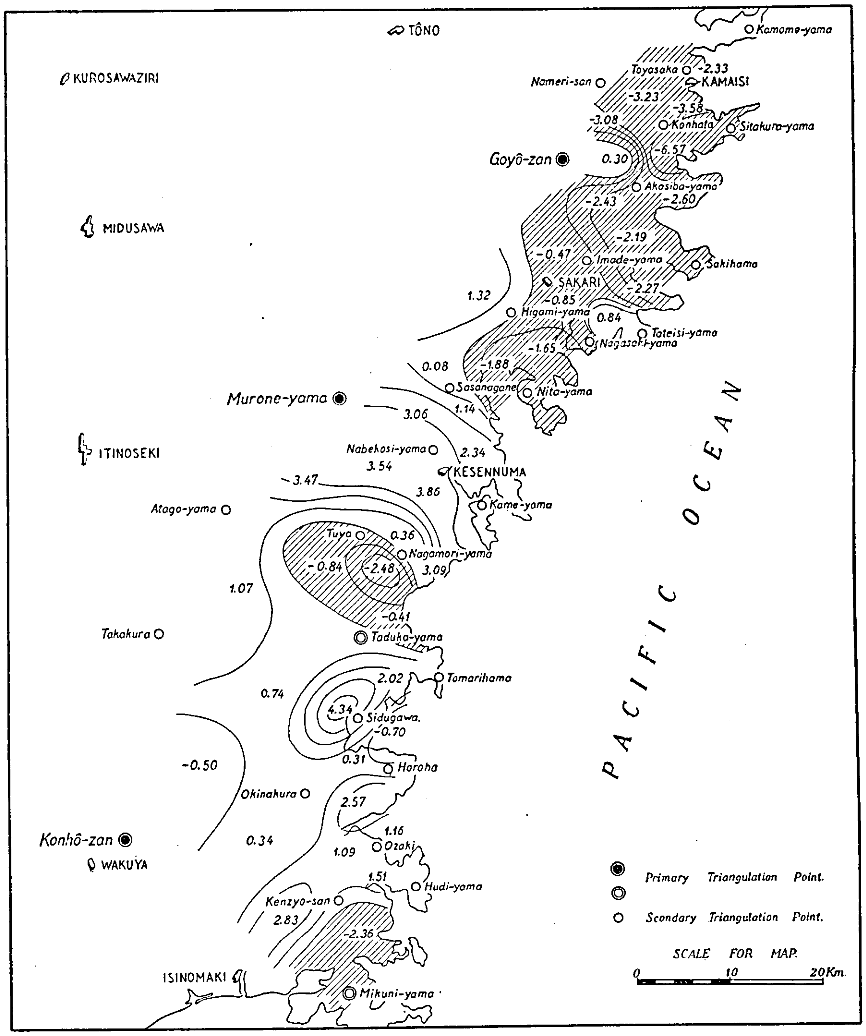

Fig. 6. Distribution of Δ of triangles formed by secondary triangulation points. (Numerical figures designate amounts of Δ in 10^{-5}).

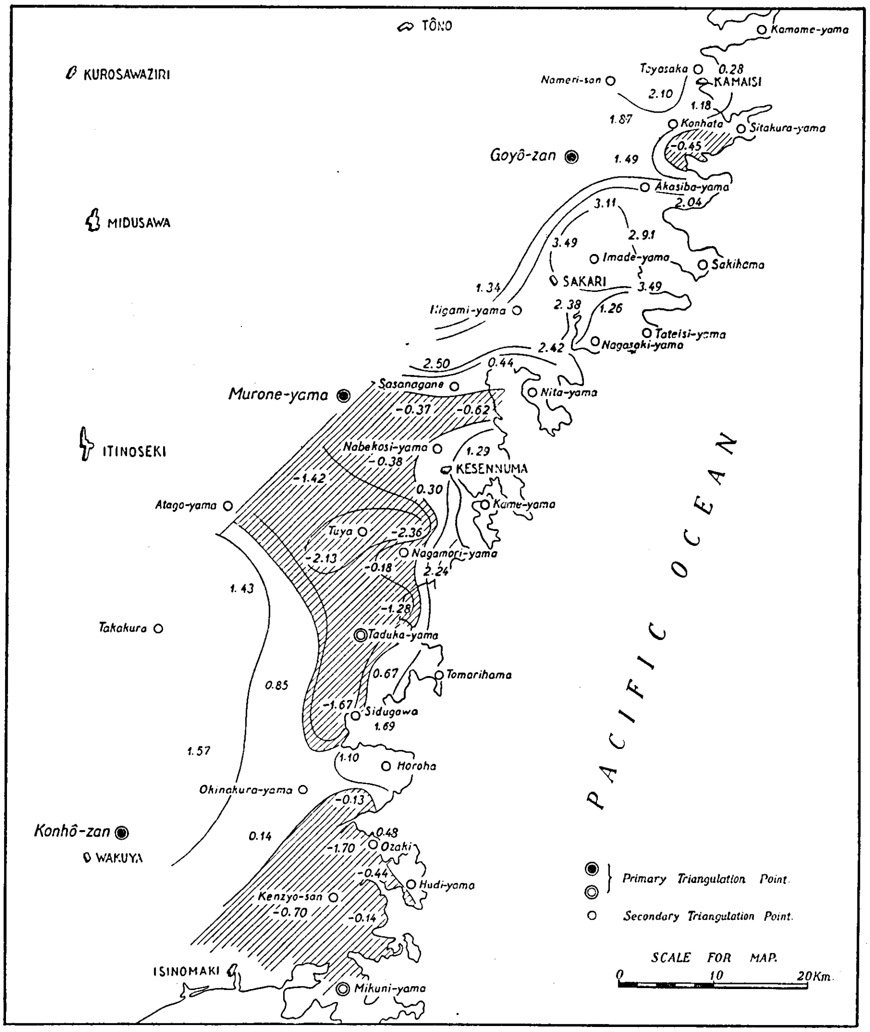

Fig. 7. Distribution of 2ζ of triangles formed by secondary triangulation points. (Numerical figures designate amounts of 2ζ in 10^{-5}).

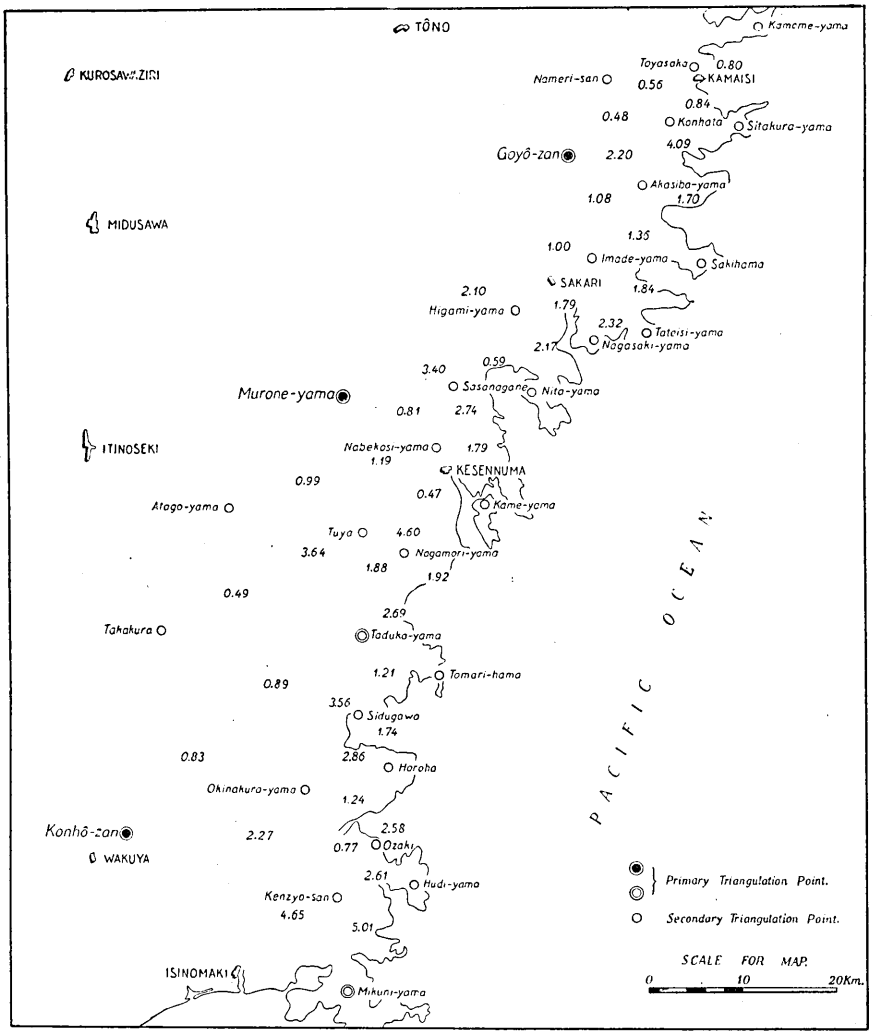

Fig. 8. Distribution of S_m of triangles formed by secondary triangulation points. (Numerical figures designate amounts of S_m in 10^{-5}).

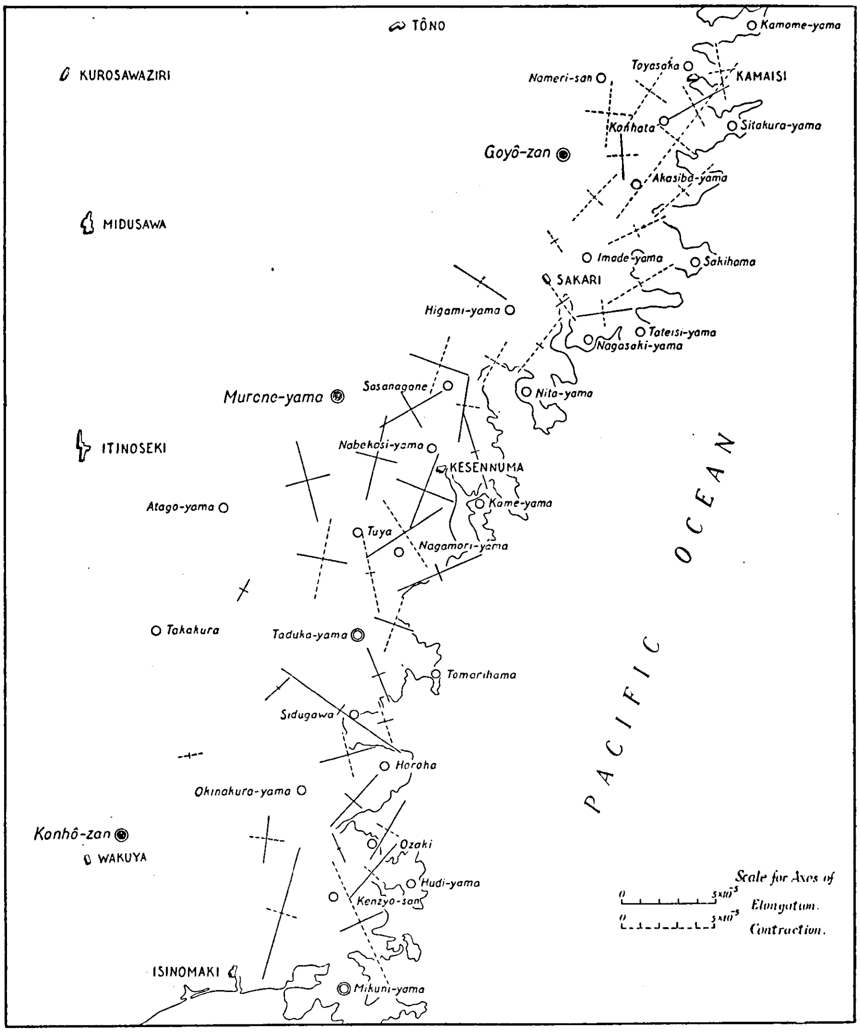

Fig. 9. Distribution of principal axes of strains of triangles formed by secondary triangulation points.

in one and negative in the next. As the triangles formed by the secondary triangulation points are generally smaller than those formed by the primary ones, it may suggest that the mode of deformation was, in detail, more complicated and conspicuous, although it was on the whole a contraction, as may be seen from the Δ's in the triangles formed by the primary triangulation points.

(ii) The geographical distribution of rotation is somewhat complicated. Disregarding their amounts, the sense of the rotational deformation of the earth's crust in this region was on the whole counterclockwise.

(iii) Judging from the geographical distribution of the principal axes of contraction and elongation in the triangles formed by the primary triangulation points, the earth's crust in this region generally had contracted in the direction E—W, while it was elongated in the direction N—S. Contraction of the earth's crust in an E—W direction may conduce an upwarping deformation of the Kitakami block.

(iv) The geographical distribution of the principal axes of strain in the triangular areas formed by the secondary triangulation points is much more irregular than in those formed by the primary triangulation points, as in the case of distribution of Δ, just referred to. We notice however that the region in which the axes of contraction and in which the axes of elongation are greater are distributed alternately along the Pacific coast, corresponding to the distribution of regions of positive and negative divergence.

It may be stated here, as has been pointed out by Dr. Tsuboi[4], that the derived amounts of crustal deformation are only relative, seeing that the points of origin (Yakeisi-dake and Raizin-tôge) were assumed not to have been displaced, so that in the event that they had been displaced, all the measured displacements would be relatively affected according to their distance from the points of origin.

4. The vertical displacements of bench-marks along the level lines shown in Fig. 1 are those that occurred during the 30 years or more interval since the previous survey. The dates of the surveys along the different sections of the level lines are given in Table II.

Table II. Dates of Levelling Surveys.

Section	Previous survey	Recent survey
Isinomaki-Ayukawa	June~July, 1900	May~June, 1933
Isinomaki-Kamaisi	Aug.~Dec., 1900	May~Aug., 1933
Kamaisi-Miyako	Apr.~June, 1901	June~Aug., 1933
Kamaisi-Kurosawaziri	Sept.~Nov., 1900	Aug.~Nov., 1933

4) C. Tsuboi, *Jap. Journ. Astr. Geophys., loc. cit.*

The results of the rerunning of level lines are shown in Figs. 10~12[5]. In these curves showing the vertical displacements of the earth's

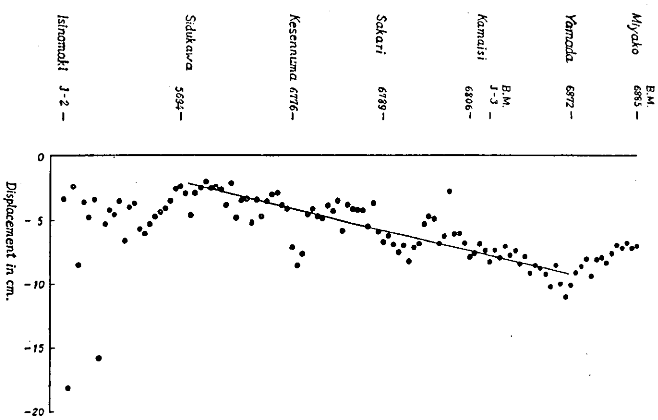

Fig. 10. Vertical displacements of bench-marks along the line Isinomaki-Miyako.

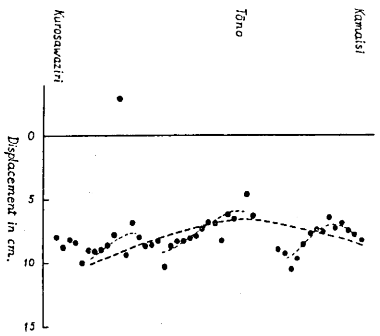

Fig. 11. Vertical displacements of bench-marks along the line Kurosawaziri-Kamaisi.

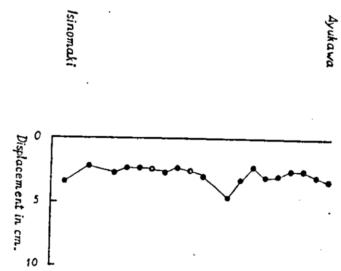

Fig. 12. Vertical displacements of bench-marks along the line Isinomaki-Ayukawa.

crust, we notice that (1) the vertical displacements are generally negative, that is, the earth's crust sank relative to the standard datum during the interval between the old and new surveys. To go into details, the depression is more marked in the north near Kamaisi than in the south near Sidukawa. The vertical displacements along the line that crosses the Kitakami mountain range, from Kamaisi to Kurosawaziri, show upwarp, which however is not readily apparent owing to considerable fluctuations in the heights of the upwarp. (2) As will be seen from Figs. 10~12, the vertical displacements along the

5) Reproduced from the *Report of the Military Land Survey, loc. cit.*

level lines fluctuate, these fluctutations being supposed to be due to irregularities in the trends of the lines, and to tiltings and other movements of the smaller crustal blocks.

The maximum amplitude of the fluctuation due to irregularities in the trends of the level lines may be

$$w' = \phi x,^{6)}$$

where ϕ is the angle of general tilting and x the maximum deviation in the position of a bench-mark from the general trend of the level line. Assuming $\phi = 10^{-6}$ and $x = 10$ km, we have for the maximum fluctuation

$$w' = \phi x = 10^{-6} \times 10^{6}\,\text{cm} = 1\,\text{cm},$$

which is of an order of magnitude comparable with the actual amplitude of fluctuation in the vertical displacements.

5. As the level lines pass through regions in which are triangular areas with secondary triangulation points as vertices, the mean vertical displacements of the bench-marks distributed in the triangular areas are compared with the Δ's of the triangles in which the bench-marks are distributed. In Fig. 13, the values of the Δ's of

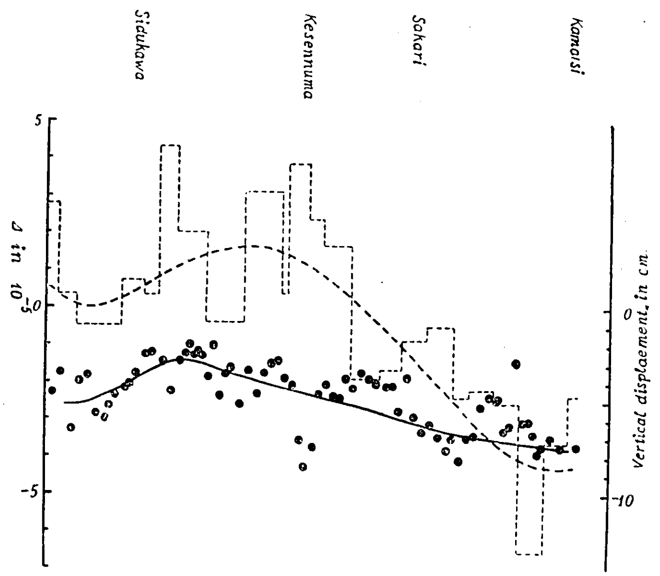

Fig. 13. Horizontal divergence and vertical displacements along the line Isinomaki-Kamaisi. (Segments of dotts the horizontal divergences, along sections of level lines in a triangular areas, the general tendency of which is denoted by a curve of dotted line.)

6) Cf. N. MIYABE, *Bull. Earthq. Res. Inst.*, 10 (1933), 278.

the triangular areas are shown by segments of dotted lines, the horizontal extents of these segments being corresponding to the lengths of the level lines in respective triangles. The vertical displacements of the bench-marks are also plotted in the same figure. Although these two curves are approximately parallel to each other in their general trends, there is a region in which the correlation between these two quantities are negative. The general positive correlation between w and Δ is also shown in Fig. 14, in which the Δ's are plotted against the $\overline{w}$'s of the corresponding triangular areas.

The positive correlation just mentioned may, in some cases, be explained by a flexural deformation of the earth's crust, as shown by Prof. Terada[7]. In this case we have, for the relation between horizontal divergence and w,

$$\Delta = \frac{\partial u}{\partial x} = -h\frac{\partial^2 w}{\partial x^2}.$$

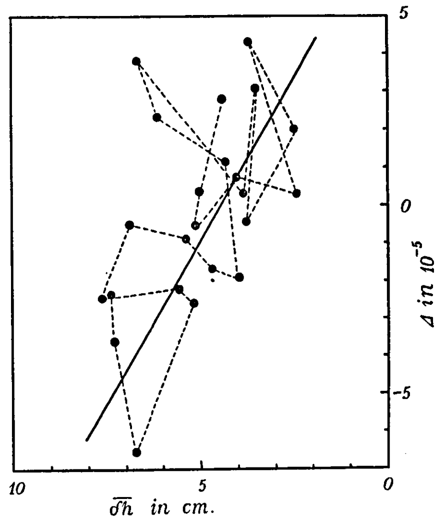

Fig. 14. Relation between Δ and $\overline{\delta h}$ in the region between Isinomaki and Kamaisi.

The correlation between the vertical movements and the horizontal divergence are not always positive, there being a number of cases in which the correlation is negative[8], so that flexural deformation does not always explain the correlation between vertical movement and horizontal divergence. If, however, the earth's crust were composed of a number of crustal blocks, tilted, upheaved, and depressed in various ways, it would be possible, by means of certain modes of block movements, to explain the positive and negative correlations between w and Δ in the region under consideration[9].

It may however be possible to explain the correlation between the vertical movements and the horizontal divergence, without considering the block movements.

When a surface layer of uniform thickness, lying horizontally between two rigid blocks, is subjected to pressure from below, as shown

7) T. TERADA, *Proc. Imp. Acad.*, **6** (1930), 53.
8) N. MIYABE, *Bull. Earthq. Res. Inst.*, **9** (1931), 1.
9) C. TSUBOI, *Jap. Journ. Astr. Geophys.*, *loc. cit.*

in Fig. 15, the horizontal and vertical displacements, u and v, at a point on the surface, are given by Prof. Sezawa[10] in the following forms: λ, the Lamé constant of the layer, being assumed to be infinite,

$$2\mu u=\sum_{m}\{A_m(-mx\sinh mx)-D_m m\cosh mx\}$$
$$-\sum_{m}\{B'_{m'}+C'_{m'}m'\}\cos m'x, \qquad (1)$$

and

$$2\mu v=\sum_{m'}(-D'_{m'}m')\sin m'x, \qquad (2)$$

where

$$m=\frac{(2n+1)\pi}{a},$$

$$m'=\frac{n'\pi}{b},$$

a=thickness of the surface layer,
b=horizontal extent of the surface layer,

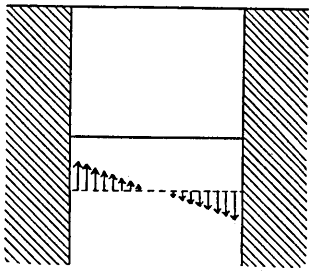

Fig. 15.
(Arrows show pressure from below.)

and A_m, D_m, $B'_{m'}$, $C'_{m'}$, $D'_{m'}$ are constants determined by boundary conditions. The value of Δ, in this case, is therefore given by

$$\Delta=\frac{\partial u}{\partial x}=\frac{1}{2\mu}\Big[\sum_{m}\{-m[A_m\sinh mx+(A_m x+D_m)\cosh mx]\}$$
$$-\sum_{m'}\{-m'(B'_{m'}+C'_{m'}m')\}\sin m'x\Big]. \qquad (3)$$

On comparing this expression with that of (2), we can say that in certain cases in which the first term of the right-hand side of (3) is negligible compared with the second term, the correlation between Δ and v, that is, the horizontal divergence and vertical movements, will be positive according to the signs of the principal terms of the series $\sum_{m'}\{-m'(B'_{m'}+C'_{m'}m')\}\sin m'x$ and $\sum_{m'}(-D'_{m'}m')\sin m'x$.

In the case of crustal deformation associated with destructive earthquakes, the block movements show themselves conspicuously, as in the case of the Kwantô earthquake of 1923 and that of the Tango earthquake of 1927. In these cases, therefore, various modes of block movements can be taken to explain the positive and negative correlations between w aud Δ. In the case of crustal deformation in Iwate and Miyagi prefectures, the deformation may be regarded rather as chronic, as will be discussed in the next paragraph. In these cases, therefore, both the block movements and the crustal deformation

10) K. SEZAWA and G. NISHIMURA, *Bull. Earthq. Res. Inst.*, 8 (1930), 13.

shown by Sezawa's calculation may be considered to be probable explanations of the correlation between w and Δ.

6. As already stated, the order of magnitude of the horizontal divergence in the region under consideration is smaller than in those of other regions disturbed by destructive earthquakes.

The frequency distribution of horizontal divergences in the triangular areas of the primary triangulation points is quite different from those of the Kwantô district, as will be seen upon comparing Fig. 16 and Fig. 17. In the case of the Kwantô district, the frequency

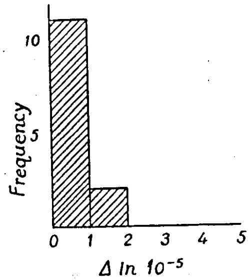

Fig. 16. Frequency distribution of Δ's of triangles formed by primary triangulation points in regions of prefectures of Iwate and Miyagi.

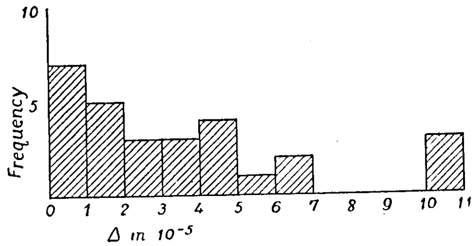

Fig. 17. Frequency distribution of Δ's of trianles formed by primary triangulation points in the Kwantô district.

maximum occurrs at a greater value of Δ. The same thing will also be observed upon comparing the frequency distribution of horizontal divergence in the triangular areas of the secondary triangulation points of this region (Fig. 18) with that of the horizontal divergence within the blocks in the Kwantô district, shown in Fig. 19[11].

These facts may suggest that the earth's crust in this regions was not greatly disturbed by the destructive earthquake of March 3, 1933. The fact noticed in the preceding paragraph that, in cases of fluctuations in vertical displacements of bench-marks along

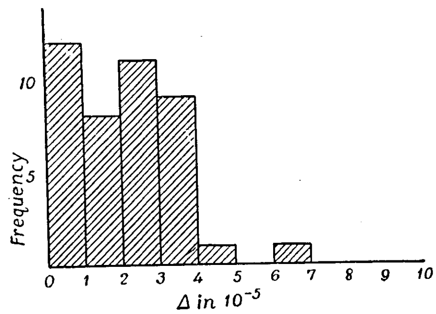

Fig. 18. Frequency distribution of Δ's of triangles formed by secondary triangulation points in the regions of of prefectures of Iwate and Miyagi.

11) The approximate extent of the crustal blocks in the Kwantô district is comparable with that of the triangular area of the secondary triangulation points in the Sanriku district, which explain the reason for our comparing the frequency distribution of the magnitudes of their horizontal divergences.

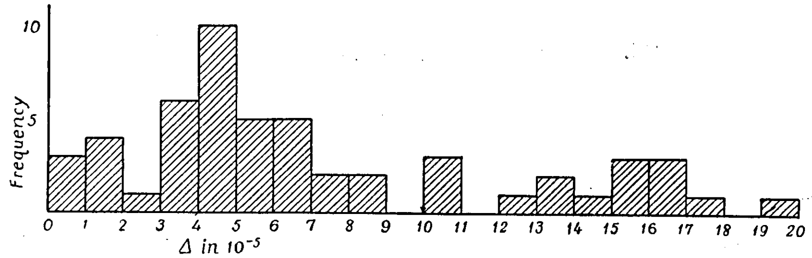

Fig. 19. Frequency distribution of Δ's of crustal blocks in the Kwantô district.

the level lines, block movements are less evident, may support the suggestion just mentioned.

Although block movements were less evident, crustal blocks exist none the less. As we have shown[12], in the quiescent stage following a considerable period of time after a destructive earthquake, or in regions where the earth's crust has not been disturbed by a destructive earthquake during the time interval between successive levelling surveys, as in the case of the Kwantô and the Tôkaidô districts, block movements are less evident, although carefull investigation confirmed the presence of crustal blocks.

7. Summary. In the present paper, the horizontal deformation of the earth's crust in Iwate and Miyagi prefectures are calculated by means of the data of horizontal displacements of the triangulation points distributed in the region under consideration. The geographical distribution or modes of the horizontal deformation are discussed in relation to the vertical movements measured along the level lines.

After comparing the frequency distribution of horizontal divergences in this region with that of the Kwantô district, it is suggested the earth's crust in this region was not disturbed much by the earthquake of March 3, 1933.

In conclusion, the writer wishes to express his sincere thanks to Professor Torahiko Terada for his valuable suggestions. His thanks are due also to Mr. S. Inomata for his assistance in calculating the horizontal deformations and in preparing the figures for this paper.

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12) N. MIYABE, *Bull. Earthq. Res. Inst.*, **11** (1933), 639.

23. 岩手，宮城縣下に於ける地殼の變形

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昭和8年3月3日の三陸の津浪を伴つた地震に關聯して，地殼の變動を調べる目的を以て，三角測量並に水準測量が行はれたが，本文に於いては，從來屢々報告したと同樣な方法で，その結果の解析を行つた事を述べてある．

今，解析の結果として得られたものゝ中で一つの重要なことは，この地域に於ける地殼の變形の程度が，關東地方などと比較して小なることである．例へば divergence について見ても，その frequency maximum が三陸では $0\sim2{\cdot}3\times10^{-5}$ のところどころにあるのに，關東地方のは $4\sim5\times10^{-5}$ 乃至は 10×10^{-5} のところにある．

又，垂直變動について見ても，地塊運動があまり明瞭でない．

是等の事實は，この地方の地殼が地震ではあまり影響を受けなかつたのではないかとの考を示唆する．