42. *Supplementary notes to the Study of Crustal Deformation in the Tango District.*

By Naomi MIYABE,

Earthquake Research Institute.

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1. In studying the crustal deformation in the Tango district with the aid of an analysis of the data of horizontal displacements of triangulation points, the existence of the Gô-mura fault and the Yamada fault, both of which appeared at the time of the destructive earthquake of 1927, was ignored, i.e., the crustal deformation was believed to be continuous over the zone traversed by active faults[1]. This, of course, is one hypothesis on the basis of which a study of crustal deformation in this district may be extended. There is however another hypothesis for reference in studying the crustal deformation, namely, that in which the crustal deformation is believed to be discontinuous in the zone traversed by active faults. Yamaguti, who recently studied the modes of crustal deformation in the Idu district based on such an hypothesis, obtained some interesting results[2].

On the basis of the above mentioned hypothesis, the study of the mode of crustal deformation in the Tango district was revised, the result being as follows:

2. In order to show clearly the mode of deformation of the earth's crust, the horizontal divergence, rotation, etc. were calculated as before[3] by using the data of horizontal displacements of the triangulation points distributed in this region[4].

Calculations of the amounts of

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

and horizontal rotation $\zeta=\frac{1}{2}\left(\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}\right)$

1) T. TERADA and N. MIYABE, *Bull. Earthq. Res. Inst.*, **7** (1929), 223—239. C. TSUBOI, *Ibid.* 8 (1930). 153—221.
2) S. YAMAGUTI, not yet published.
3) C. TSUBOI, loc. cit. 1).
4) Rikuti Sokuryôbu (Military Land Survey), Report issued in 1930.

were made for regions I, II, III, separately, divided by the lines *AB* and *CD* representing the general trend of the Gô-mura fault and the Yamada fault, as shown in Fig. 1.

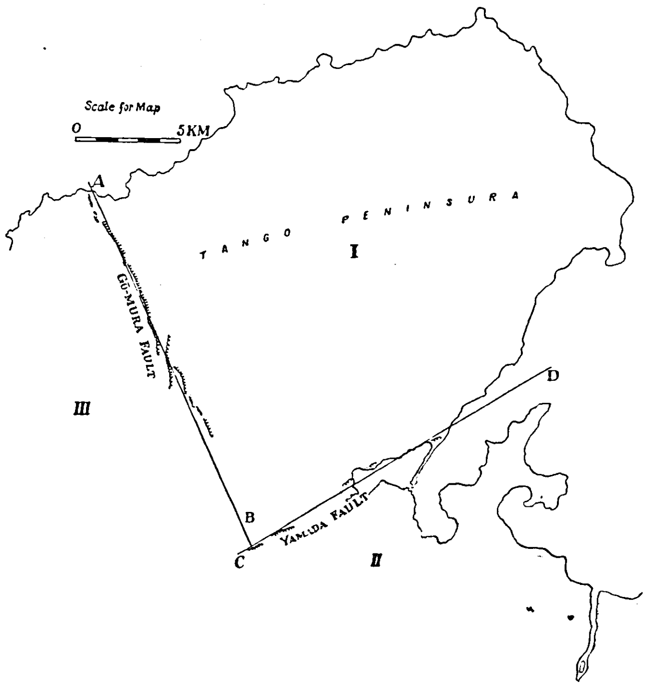

Fig. 1. Regions I, II, III in Tango district.

It is possibly a question whether the westward elongation of the line *CD* (the Yamada fault) ever really existed or not. However, in the zone into which the Yamada fault prolongs itself, the amounts of horizontal displacements are generally smaller and no trace of the active fault was apparent. Therefore, the horizontal deformation of the earth's crust was tentatively regarded as continuous over this zone. The distribution of the horizontal divergence Δ and rotation ζ thus calculated are shown in Figs. 2~3 respectively.

Except in certain respects, the mode of distribution of these quantities i.e., the mode of horizontal crustal deformation, is very similar to those obtained in the previous investigations[5].

The values of Δ in region I are generally positive, especially in the part close to the Gô-mura fault, while, in region III, contiguous to the west of region I, the values of Δ are negative. In previous inves-

5) C. TSUBOI, *loc. cit.* 1)

tigations, the configuration of equal contour lines was greatly deformed by the greater amount of negative divergence in the zone along the Gô-mura fault, which however is not observed in the results of the recent study.

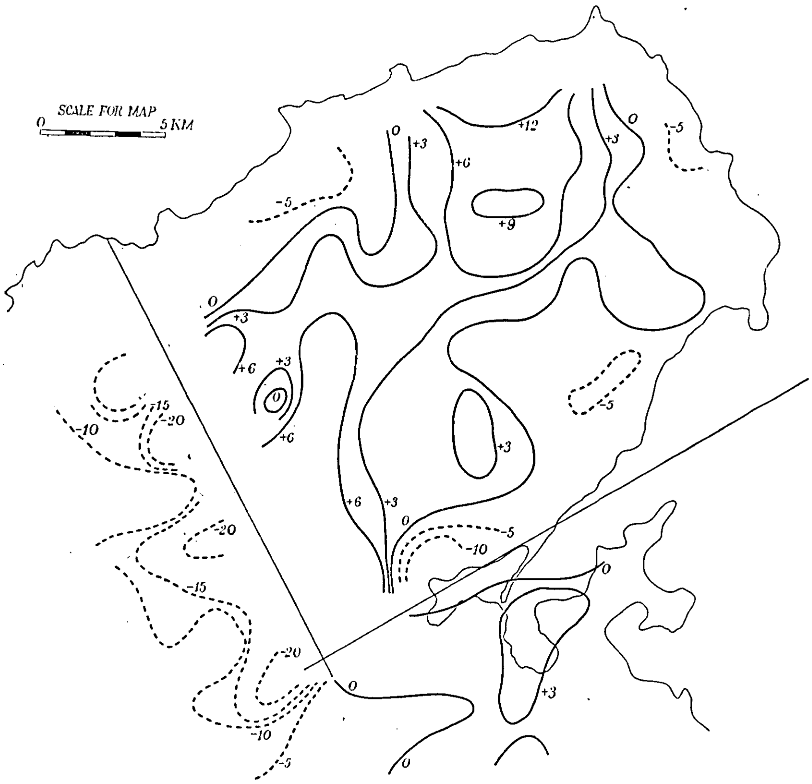

Fig. 2. Distribution of horizontal divergence. (Numerals against contour lines designate amounts of divergence in 10^{-5})

In constructing Figs. 2~3, the values of the horizontal deformation were calculated for every 2^2 km. The modes of crustal deformations studied here are therefore those obtained through a mesh of only 2×2 km, so that it is not possible to go into greater detail regarding the mode of crustal deformation from the present result of analysis.

In Fig. 4, the frequency of squares of 2×2 km is plotted against the values of Δ. Frequency curves I and III correspond to regions I and III respectively.

From the curves in Fig. 4, we notice (i) that squares whose values of Δ are small are generally speaking more frequent than those whose values of Δ are large, and (ii) that in curve I showing the frequency of squares with regard to Δ in region I, a maximum occurs at $\Delta = 7 \times 10^{-5}$.

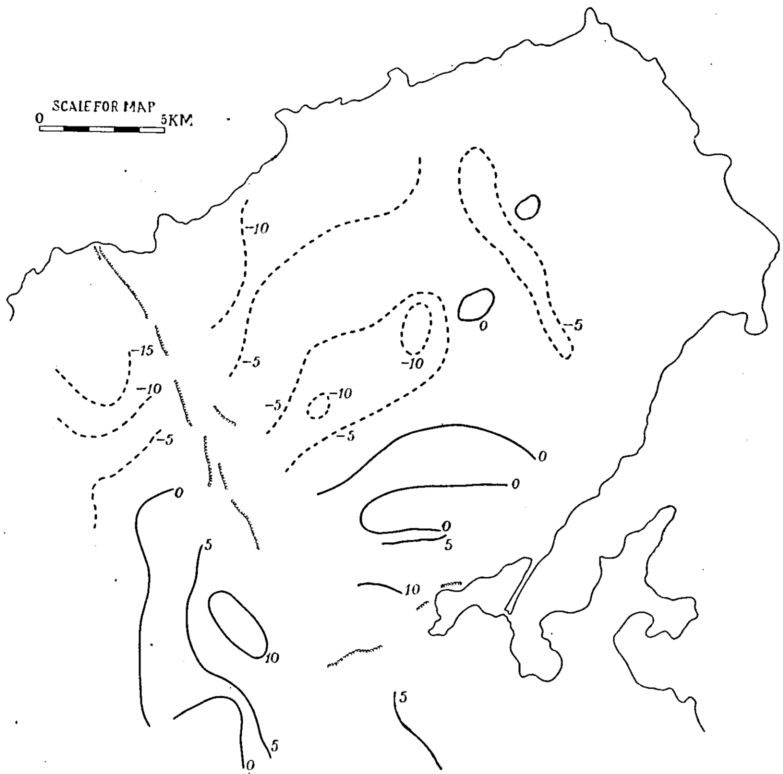

Fig. 3. Distribution of rotation. (Numerals against contour lines designate amounts of rotation in 10^{-5})

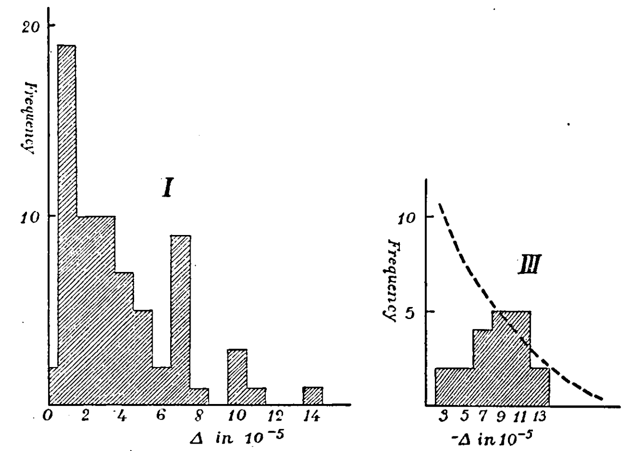

Fig. 4. Frequency distribution of Δ in regions I and III.

The former corresponds to the fact that the crustal deformation associated with this earthquake is localized within a relatively limited area, in fact, in a zone including the Gô-mura fault, the latter probably indicating that the earth's crust in the Tango peninsula was in general deformed as much as 7×10^{-5}.

3. We may expect to obtain some hints in explanation of the mechanism of crustal deformation by comparing the amounts of horizontal deformation with the vertical movements.

In comparing the horizontal divergence with the vertical earth movements[6], we notice at a glance that in region I, the horizontal divergence is generally positive, showing that the earth's crust was depressed, while, in the adjacent region III, west of the Gô-mura fault, the horizontal divergence is negative, showing that the earth's crust was elevated. Especially in the neighbourhood of the southern end of the apparent Gô-mura fault, the earth's crust was elevated conspicuously and the horizontal divergence fairly large and negative.

To study the above mentioned fact systematically and statistically, a diagram was constructed by plotting the values of the horizontal divergence against the values of the mean vertical displacements, δh, calculated for every 2×2 km the same squares as those for which the horizontal divergence was calculated. The result is shown in Fig. 5. Since the points in this diagram are widely dispersed, the linear relation between Δ and δh cannot be readily seen.

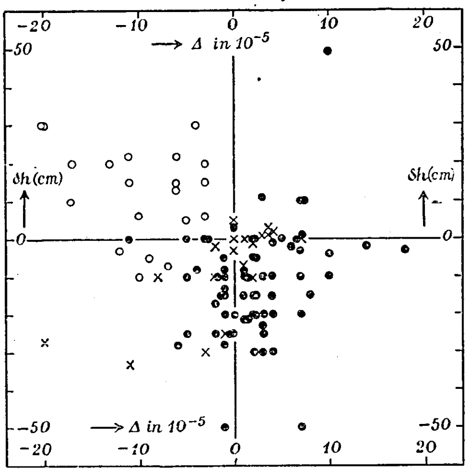

Fig. 5. Relation between Δ and δh in regions I (●), II (×), III (○).

We notice however that the points representing the relation between Δ and δh of region III, (that west of the Gô-mura fault) are distributed mainly in the second quadrant, while those of region I (that east of the Gô-mura fault) are distributed mostly in the fourth quadrant. This means that the correlation between Δ and δh may, if the points of region I and III are grouped together, be regarded on the

6) Rikuti Sokuryôbu (Military Land Survey), Report issued in 1930.

whole as negative, i.e., that part of the region where the earth's crust was contracted horizontally has been elevated and the depressed part of the region has elongated horizontally.

The points representing the relation between Δ and δh of region II are mostly concentrated in the neighbourhood of the origin of the coordinates, showing that crustal deformation in this region was not so marked as in other regions, either in horizontal or vertical direction.

If, however, a number of points distributed in the third quadrant, and representing the relation between Δ and δh of a part of region III adjacent to region II were grouped together with those concentrated in the neighbourhood of the origin of the coordinates, the correlation of Δ with δh will be positive.

4. From the distribution of rotational deformations, as shown in Fig. 3, it will be noticed in rather a conspicuous way that, in the neighbourhood of the southern end of the Gô-mura fault, the earth's crust was rotated counter-clockwise, while in the neighbourhood of Amino, i.e., near the northern end of the active Gô-mura fault, it was rotated clockwise. In other parts of the region under consideration, the difference in the modes of rotational deformation was not conspicuous.

The enormous rotational deformation in the zone including the active faults, as just shown, is due to the fact that the direction of the horizontal displacemants of the triangulation points distributed in different parts of the region through which Gô-mura fault passes, are opposite to each other, the amounts displaced being as large as 1 metre or more.

5. Next the horizontal displacements of each of triangulation point was reduced into two components, i.e., the component parallel to the general trend of the Gô-mura fault and the component perpendicular to it, the direction of the general trend of the Gô-mura fault being taken as N24°W, as shown by line *AB* in Fig. 1.

The distribution of the components of horizontal displacements perpendicular and parallel to the general trend of the Gô-mura fault are shown in Figs. 6 and 7 respectively.

From Fig. 6, the perpendicular components of the horizontal displacements appear to be continuous over the area that is traversed by the Gô-mura fault, their amounts generally being smaller in the eastern part of the fault than in the western part. As the sense of direction of these components is from east to west, the Gô-mura fault is thought as being made apparent by the crustal deformation to widen the crack of the fault, so far as the distribution of the perpendicular

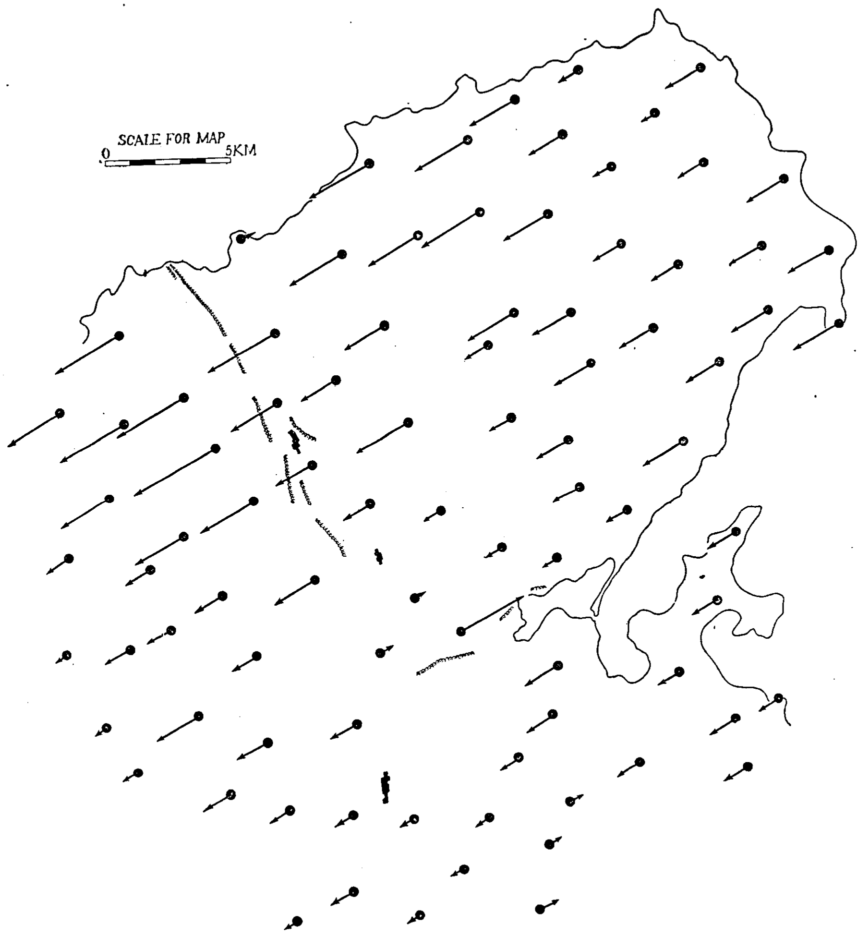

Fig. 6. Distribution of components of horizontal displacements, perpendicular to the trend of the Gô-mura fault.

components of the horizontal displacements shows.

A similar feature is also noticed in the parallel components, i.e., the components approximately perpendicular to the trend of the Yamada fault, as shown in Fig. 7.

It will also be noted that on different sides of the fault lines, the directions of the components of horizontal displacements parallel to their trends are reversed.

In the zone on the westward elongation of the Yamada fault, which elongation was not apparent at the time of the destructive earthquake, the components perpendicular to its trend show a contraction of the earth's crust while the components parallel to its trend do not show

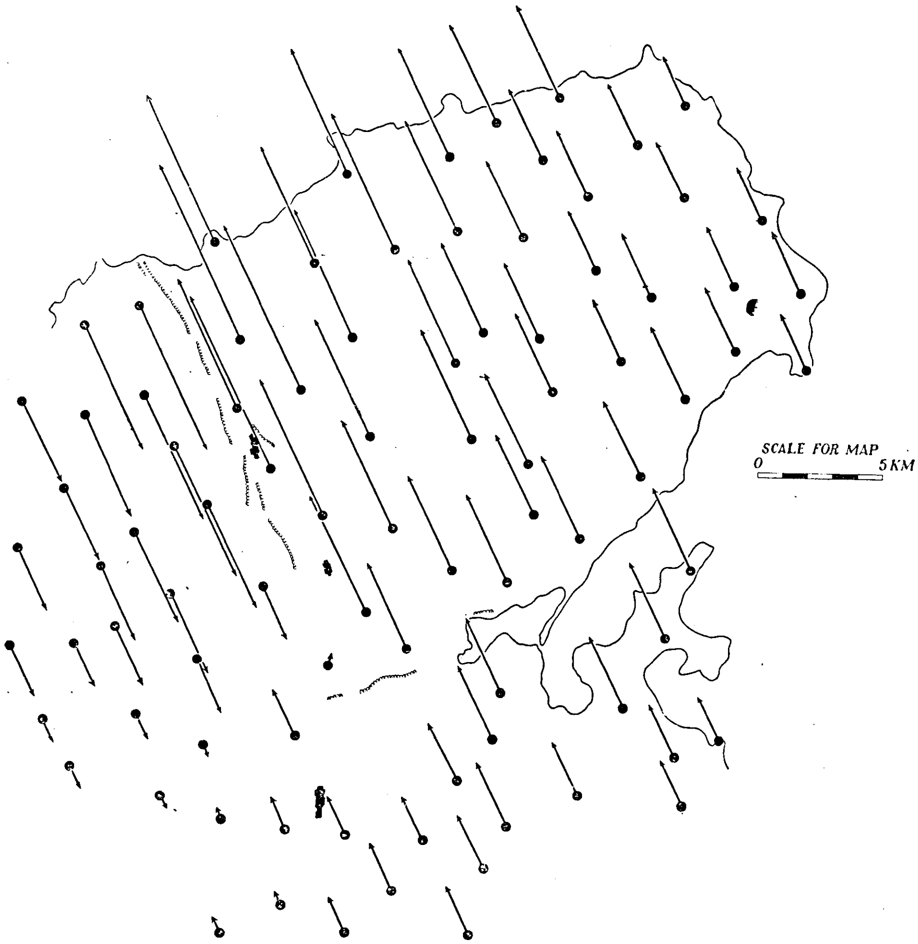

Fig. 7. Distribution of components of horizontal displacements, parallel to the trend of the Gô-mura fault.

any signs of shearing deformation, having a burried fault-plane as a shear plane, so far as observed in zones where the fault lines are readily apparent.

Lastly, it should be remarked that the method of investigation described above is one way of studying the crustal deformation associated with the destructive Tango earthquake.

As the mechanism responsible for the appearance of faults on the surface of the earth, there may possibly be explanations, the results of analysis based on which may differ in several respects from the present results described in this paper. The question then arises, what is the most probable explanation of the mechanism that brings about crustal deformation? We cannot, at present, answar the question, for we are not aware of any fact that would be a criterion of the question asked.

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42. 丹後地方の地殼變形研究補遺

地震研究所 宮部直巳

丹後地方の地殼變形に關する坪井氏の研究並に筆者等の前報文に於いては，郷村斷層及び山田斷層の存在を無視し，これ等の斷層の過る地帶を通しても，地殼變形が連續的であつたと假定してある．これ等の斷層を境界とする兩側の地域での地殼變形は，この斷層地帶で不連續的であるとすることも亦一つの考へ方であるから，本文に於いては，さういふ見方で問題を取扱つてみた．その結果は，大體の變形の分布方式は以前に報告した所と大差なく，斷層地帶に於ける大なる變形の影響は豫期される通りなくなつてゐる．

又，水平移動を郷村斷層に略直角なる方向と，之に平行する方向との2成分に分析してその分布を調べてみると，斷層の新らしい割目の出顯した地域では，斷層に直角の方向には何れものびたやうな變形をなし，平行の方向に著しい *shear* のあつたことが認められた．併し，出顯した斷層の延長上の地帶では，この假想的斷層線に直角の方向には押し合び，之に平行なる方向に於ける *shear* は著しくない．
