16. *On the Geophysical Significance of the Crustal Movement Found after the Great Earthquake of 1923.*

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Admitting the vertical displacement of the sea bottom in Sagami Bay deduced from the results of soundings as valid in its essential features,¹⁾ a question naturally arises whether the change had taken place gradually in the interval between the two epochs of observation, or it was mainly completed at the time of the earthquake. As a local secular movement of the earth crust seems to be taken as granted on the basis of many sources of evidence, we must admit at least some part of the displacement found as due to this cause. On the other hand, there is an indisputable evidence of the fact that in the coastal region of the district, the greater portion of the vertical movement was completed within a short duration of time directly connected with the earthquake. If the different features of the crustal movement should be considered as related to each other forming a system and not of independent origins it will be plausible to assume that at least the greater parts of the different components of movement occurred directly associated with the earthquake.²⁾

Next question arises as to the amount of the vertical movements in the sea bottom which seems to be of quite different order of magnitude compared with that found in the land area.³⁾ Such a contrast will appear improbable as long as we assume the identity in the physical nature of the crusts forming the land area and the deep sea bottom. If we admit, according to the modern view of the structure of the crust, that the deep sea bed is composed of a decidedly more plastic material than the land block, the state of things here disclosed may appear not quite improbable. For illustrating what is here meant to

1) See the preceding paper No. 14 by the same author, this Vol.

2) The argument occasionally made that if the recorded change was effected at the time of earthquake, the sea-waves caused must have been far more conspicuous, is not necessarily valid, since the change might have been effected sufficiently slow and, moreover, the integral effect of the positive and negative movement might have cancelled each other.

3) The test by the continuity equation, i.e. by the comparison of volumes displaced by the vertical movements, seems at present hopeless, as the area surveyed is limited to a small region.

say, a simple experiment may be cited. A quantity of "*miduame*" is kept in a basin to a depth of a few cm. Its superficial layer is made somewhat harder than the interior by a long exposure to dry air. A piece of wooden block floating on the surface may be pushed horizontally by a small force applied by hand. In this manner, an irregular system of folds or creases of considerable relief may be produced. The horizontal dimension of the fold, i.e. the "wave length," seems to be determined partly by the thickness of the hardened layer. In the meantime, the wooden block shows, of course, no sensible deformation, except some small translational and rotational motion besides the intended horizontal shift. It suffices then to say that the land block and the deep sea bottom behave respectively more or less analogous to the wooden piece and the layer of hardened *miduame*, an idea shared by a number of geophysicists, if not all.

Another question may be raised as to the manner in which a vertical displacements of the order of several ten metres may be brought about by a horizontal movement of only one metre or so. To answer this, we may again resort to a simple experimental model. Let AB, BC, CD and DE be four pieces of rods placed upon a table in successive juxtaposition such that ABCDE forms a straight line. Let a straight ruler be applied on one side of the row for a constraint against the motion of the rods. Next, push the two pieces AB and DE towards each other along the ruler, till the other two pieces, BC, and CD is deflected from the original straight line. Assume that the rods are still linked at the points B, C and D. Let $BC=CD=l$, the decrease of the distance $BD=\xi$ and the distance of the deflected position of C from the ruler $=\eta$, we have $\xi=2l(1-\cos\theta)$ and $\eta=l\sin\theta$, where θ is the angle of deflexion of the rods. Thence, for a small value of θ , η is of the first order, whereas ξ is a small quantity of the second order.

In the preceding paper it was shown that roughly speaking,¹⁾ the Kwantô district was compressed in the direction NE-SW, and the compression was remarkably "localized" in the region nearly coinciding with the epicentral district as well as the position of the zero line of vertical displacements in the sea bed. Summing up together what we have seen and discussed in the preceding and the present papers, we may picture a probable process of deformation effected somewhat in the following manner. The said compression resulted, in the land block mainly as an yielding in the horizontal direction owing to the insufficiency of raising a sensible vertical fold, whereas in the

1) Viz., putting out of account all the local irregularities and taking the entire district as a whole.

submarine part of the crust it resulted in a kind of irregular folding owing to the characteristic pliable nature of this part. It may be added that the potential energy claimed by the folding may be sensible reduced by the presence of water above the bed.

The horizontal displacements in land stations showed, besides the above mentioned compression, another component perpendicular to the direction of compression. This latter component was in the opposite directions on both sides of a zero line running in SE-NW direction and showed two "poles," one at Miura Peninsula and the other towards W. of Ôsima.¹⁾ Such a type of displacement may be brought about by a process of "rebound," as is usually assumed in the similar cases. It may, however, be also regarded as a case of "local horizontal folding" appearing as a secondary feature of deformation accompanying the general compression of the heterogeneous crust.

The absence of a conspicuous fault caused by this earthquake in the land area seems to be favourable for the latter idea, though these two alternatives may well turn out to be only different expressions of the same thing.

Prof. Fujiwara²⁾ recently made an interesting experiment with regard to the same problem as is here concerned, by using a plate of rubber which is fixed at a point and deformed by applying a suitable system of forces to it. The results of his experiments seem to harmonize with the essential content of the present note, at least under the author's point of view.

1) See the foregoing paper No. 15, this Vol.

2) Communicated at the meeting of the Earthq. Res. Inst.; not yet published.