18. *Active Tilting of Land Blocks.*

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(Comm. Feb. 12, 1928.)

Any tilted block bordered by active faults may naturally be called an active tilted block. In most cases the faults are formed in a moment along with the tilting of land blocks, as we have well observed in the recent great earthquakes of Kwanto, Oku-Tango, etc. On the other hand we may expect another kind of tilting, which does not happen so instantaneously but needed a long duration of time and restless movement to come to its present state. Thus the writer is trying to distinguish two kinds of tilting with reference to the period of their formation, namely: the acute and the chronic. The former is met with often in the earth-disturbances as above mentioned, but the movement of the latter is to be determined only through repeated accurate levellings over a long period of years.

It seemed very probable in such land as the Japanese Islands consist of, standing, as they do, on an alive structure of the Pacific borders, to expect the occurrence of some examples of chronic tilting, but such were never actually met with until quite recently, when the writer found a typical example in the precise levelling along the coast of the Sea of Japan. The regular repetition of levelling in certain unstable lands had been a long cherished desire of Japanese scientists and it was realized only recently for the first time. One of the surveys, which the writer would like to mention specially here, is that undertaken between the towns of Itoigawa and Nagaoka in the lithoral province Echigo along the Sea of Japan. At the request of Dr. A. Imamura and the writer, and assisted by the generous grant of the Imperial Academy, the precise levelling was undertaken from July to November in 1927 by Messrs. Yamada and Kasa of the Land Survey Department of the Imperial Army, under the supervision of Major-general Omura, the chief of the Department. The result was exceedingly interesting, especially in connection with chronic tiltings.

Before going into results of the levelling let us glance a moment at the topography and geology of this district. As we may observe on the accompanying map, there is the lofty Hida Range to the west of this district. It is the highest mountain range in the main island of

The Geology of West Echigo and the Results of the Levelling along the Coast in 1927.

Japan with many peaks of 3000 meters in altitude, hence often called the "Japanese Alps." It consists mostly of pre-Tertiary formations, old eruptive rocks, and is capped here and there with young volcanoes. Very remarkably this range makes a gigantic scarp to the east, and at its foot the tectonic valley of the River Hime-kawa and the depressed trench of Matsumoto-daira stretch. The north end of the range terminates abruptly in the precipitous cliff of Oya-shirazu on the Sea of Japan.

Very sharply separated by these tectonic lines, the district to the east of them is quite different in its land forms and geology. It consists mostly of oil-bearing marine formation of the Tertiary period, through which younger volcanic rocks were erupted making some gigantic cones, as Myoko-zan, Yake-yama, etc. The general trend of the strike of this Tertiary strata is S.W.—N.E.

The Tertiary terrains in the coastal region are separated into two parts, the Nishi-Kubiki block and the Kariha-Higashi-Kubiki block by a deep sunken embayment of lowland called the Naka-Kubiki depression. The Nishi-Kubiki block is sharply truncated in its east side by a fault line scarp in N.—S. direction, similarly to the way we have shown it is, in the west. The topography of the Tertiary hills of this block does not manifest any peculiarities, especially in their southern part, where they are mostly covered by young lavas and other ejectamenta. On the other hand the Kariha-Higashi-Kubiki block in the east is composed of some parallel ranges of Tertiary hills, with an varying altitude between 200—600 meters on an average. The trend of the ranges coincides with that of the strike of the strata. The west end of these hills is sunk in the lowland of the Naka-Kubiki depression, while the east side of them is terminated by the longitudinal valley of the River Shinano-gawa. Yoneyama is a young volcano in this region prominent on the coast and makes a good landmark for sailors.

Local earthquakes have been often experienced in these regions. Especially the severe shocks in the coast district in 1614, 1699, and 1751 are recorded in history. The regions along the River Shinano-gawa became the epicentres of severe earthquakes several times, in 841, 1714, 1718, 1828, and the great earthquake of 1847 is well known as the "Zenkoji Earthquake." The disturbance continued to recent times and some strong shocks were felt in 1888, 1889, 1890, 1897 and 1918.

The precise levelling of these regions was carried on for the first time in 1894. In comparing the results of that survey with those of the new levelling, which was repeated some thirty-five years later, very interesting is the change of level and the mode of disturbances of the

both Nishi-Kubiki and Kariha-Higashi-Kubiki blocks. As a whole both blocks have subsided since the previous levelling, with a few exceptions of some benchmarks near Kujiranami in the Kariha-Higashi-Kubiki block, which are only 3-4 mm upheaved. The amount of the subsidence varies between 2 mm and 113 mm. Very remarkably it decreases as we proceed from west to east in each block until it becomes minimum near the east end of the block, where it increases suddenly to its maximum, making a steep gap in the line, as it is shown at the top of the figure. In the Nishi-Kubiki block it is -94 mm in the west end and gradually decreasing to -38 mm in the east, it increases abruptly to -113 mm in Naoetsu along the old fault line. In the Kariha-Higashi-Kubiki block it begins with -96 mm in the west and becomes +4 mm in the east, while it increases suddenly to -70 mm. Very obviously the movement of each block is in subsidence, which is not at a uniform rate in each benchmark, but makes a tilting with its scarp side in the east coinciding with preexisting fault lines, and the back slope in the west. So the tilting has occurred in the same sense in both blocks and the subsidence is greater in the west block than in the east. These tilting movements have been performed during these thirty-five years without any sudden disturbances of the land feature, such as the formation of new clefts or fault lines, but very slowly and continuously for a long interval of time. It must be specially remarked that the tilting is active and chronic.