84. *On the Mesozoic and Tertiary Crustal Movements in the Kuan-tung Province, South Manchuria.*

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Since the days of the pioneer work of von Richthofen it has been generally accepted that the Liao-tung Peninsula with its southwestern tip, the Kuan-tung Province is an area of Pre-Sinian folding. The writer's observation during the past five years, however, has revealed that it is not the case in the Kuan-tung Province, where intense foldings accompanied by thrustings occurred in the Mesozoic (probably in Late Jurassic or Middle Cretaceous) and fault movements in the Tertiary.

The geological formations (pre-Quaternary) in the observed part of the province are tabulated in descending order as follows:—1)

9. Chien-shih-hui-yao-tzu (前石灰凝子) Series (Anthracolithic), 400 m.
   ..........disconformity..........
8. Aikawa (愛川) Series (Middle Ordovician), 220–350 m.
7. Chiao-mai-shan (喬麥山) Series (Lower Ordovician), 300–360 m.
6. Chi-ting-shan (七頂山) Series (Middle and Upper Cambrian), 360–400 m.
5. Chin-chow (金州) Series (Lower Cambrian), 600–1400 m.
4. Kuan-tung (關東) Series (Sinian, i.e. Neo-Proterozoic), 3600 m.; limestone, dolomite, etc.
3. Ta-ho-shang-shan (大和尚山) Series (Sinian), 3200 m. +; quartzite, clay slate, etc.
   ..........clino-unconformity and disconformity..........
2. Gneiss complex.
   ..........intrusive contact..........1
1. Hsiang-shui-szu (馨水寺) Series (Eo-Proterozoic); mica-schist, phyllite, crystalline-limestone, etc.

It may be an interesting fact that the Sinian and Palaeozoic formations in the Kuan-tung Province are thicker and have fewer gaps of sedimentary record than those in the other part of South Manchuria. The writer agrees with Mr. T. Kobayashi2) on the former existence of a geosyncline extending from South Heian-dō (平安南道) in Korea to

1) Refer to the writer's papers:—
   2. On the geology of the area between Chinchou and Choushuitzu—in the Kuantung Province, South Manchuria, (in press).
   3. On the geology of the larger part of the area between Ryojun and Dairen, Kuantung Province, South Manchuria, (in press).

2) T. Kobayashi:
Kuan-tung Province, and the writer intends to call this the Heinan-Kuan-tung geosyncline. Since the relations between each series are really or apparently conformable, showing no sign of crustal movements except epeirogenic ones, it is manifested that through the long period of geologic history from the Sinian to the Permian the Kuan-tung Province was in a state of quietitude.

The whole sedimentaries with a total thickness of more than 9000 metres were subjected several times to intense crustal movements. An inspection of the annexed geotectonic map will show that the fault-lines are not affected by the fold, while the fold-axes are greatly displaced or sometimes winded by the faulting. Accordingly we must infer that the folding preceded the faulting.

The structure of the folds is neither simple nor regular. Their general trend is NW to WNW in the district north of Chin-chou and NNW in the area between Ryojun (Port Arthur) and Dairen (see fig. 1), but the fold-axes often branch and sharply curve, and sometimes wind zigzag, and very commonly pitch, tending to form domes and basins.

Most of the larger folds are overturned toward NE to ENE (rarely N) indicating the considerable intensity of the folding. It is supposed that two larger anticlines running NW-SE in the vicinity of Chin-chou were so intensely overturned that their northeastern limbs were torn off, resulting in two low-angle thrusts (see fig. 2). The writer gives them provisional names: Chin-chou thrust and Nan-shan (南山) thrust.

The period of compressional horizontal stresses (i.e. of folding and thrusting) is inferred to have been followed by relaxational period during which normal faults are formed. Thus in the vicinity of Chin-chou normal faults run in the same direction as that of the fold-axes and thrust faults.

As shown in the annexed map, there are curving and winding of fold-axes especially in the area between Dairen and Ryojun; E-W thrust faults are seen along the northern coast, also through a small peninsula north of Dairen and at the south of Ying-cheng-tzu (營城子); and a NE thrust fault near Chang-ling-tzu (長嶺子). The writer is of opinion that these features are due to the compressive horizontal forces apparently from the south.

Now this second period of lateral compression had ended, then came the long period of relaxation. The fault movements are judged to have occurred in the following order.

1) normal faults running ENE to E-W (rarely turning to NNE).
2) ,, ,, ,, WNW.
3) ,, ,, of the Sinian direction, i.e., NNE.
4) ,, ,, of the Korean direction, i.e., NNW (seldom curving to NNE).
It is to be noticed that all the fault-lines do not run straight, but irregularly curve and sometimes branch, and that there are faults with considerable amount of horizontal displacement, and also rotatory faults. The faults of the first stage greatly influence the general outline of the Kuan-tung province, especially of its southwestern half, and one of them separates the Sinian from the gneiss complex in the area east of Chin-chou. The faults of the second stage are not much conspicuous. Those of the Sinian direction are very marked all over the region surveyed, in the area north of Chin-chou their development being the most remarkable. The writer calls a set of them separating the Sinian-Palaeozoic sedimentaries from the gneiss complex the Chin-chou fault. The development of the faults of the Korean direction is not less remarkable than that of the preceding ones.

It must not be overlooked that except the larger land forms the present morphological features are not directly affected by the faultings above stated, but are greatly influenced by the difference of the lithological character.

It is interesting that there is a flat surface (seemingly a remnant of an elevated peneplain) forming the top of a long hill called Ping-shan (平山) about 300–330 m. high at the north of Chin-chou and cutting faults of all successive stages mentioned above. It may be inferred, therefore, that fault-movements had ended before the formation of the said peneplain, though there are evidences of recent slight warping.

Although we have no material which may determine the exact date of crustal movements in the region surveyed, it is apparent, as stated above, that the intense movements did not take place till the Permian Period. According to some geologists of the South Manchuria Railway Co., the Lower and Middle Cambrian sediments are thrust upon the Middle Jurassic coal measure at the Cha-tzu-yao (乍子窪) colliery near Wa-fang-tien (瓦房店) about 70 km. northeast of Chin-chou. Consequently it may not be improbable to infer that also in the Kuan-tung province lying so near Wa-fang-tien the foldings and thrustings occurred in some period after the Middle Jurassic. On the other hand it is now a confirmed and well-known fact that since the Sinian Period eastern North China and Korea never experienced intense movements until the Late Jurassic.

The accumulated informations on the Late Jurassic

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1) It must be remembered that before the work of the Chinese geologists became vigorous geological surveys had been made in China by Japanese geologists. Recently Prof. S. Yamane, one of those Japanese geologists, made a valuable contribution (mentioned below) to the tectonic geology of North China, on the basis of his observation in the course of the journeys that he made between 1918 and 1921 in southeastern Shan-si and its neighbouring districts.

Movement in eastern North China were summarized several years ago by Dr. W. H. Wong, who named it the Yen-shan Movement. It is highly probable, therefore, that the fold- and thrust-movements in the Kuan-tung province lying halfway between eastern North China and Korea are correlated to the Yen-shan Movement, which may be included in the "Jungkimmerische Gebirgsbildung" of Prof. H. Stille.

The writer considers with T. Kobayashi that the Heinan-Kuan-tung geosyncline above mentioned was transformed into the Yellow Sea folding zone in the Late Jurassic. In the case of the region under consideration the folded area is held between the two large masses of Liao-tung and Shan-tung, from both of which was probably exerted compressive force, the direct cause of the folding.

Though we are not provided with any clue in the region surveyed to determine the exact date of the fault movements, it may be most likely taken as the Middle Tertiary, since it is now fairly certain that in eastern North China and also in Korea remarkable fault movements (included in the Nan-ling Movement of Dr. Wong) occurred in the Middle Tertiary (Late Oligocene to Miocene). It is highly probable, therefore, that the elevated flat surface regarded as the remnant of an old peneplain at the north of Chin-chou was formed in a later date than the Pei-tai Stage of P: Palaeozoic; SK: Kuan-tung Series; ST: Ta-ho-shang-shan Series. N: Nan-shan Thrust; C: Chin-chou Thrust.

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2) Read the scale in this figure 1:2,000,000 instead of 1:1,000,000.