The Oku-Tango Earthquake of 1927.

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CONTENTS.

昭和二年の奥丹後地震（地形學的考察）

所員 山崎直方
所員 多田文男

梗概

若狹灣の周圍には此灣を中心として放射狀に走る斷層と共心圓狀に走る斷層とが著しく發達して居て、此等によつて此地方は大小種々の地塊に分たれ、複雜なる寄木細工的の構造をなして居る。此等の斷層に沿うては屢々地震が繰返された。其著しい例は根尾谷斷層による濃尾地震、養老、鈴鹿兩山脈間の斷層角窪地より北方敦賀灣陷落地帶に達する顯著なる構造線に起つた弘野地震、江濃地震其他の小地震であり、又近くは大正十四年の但馬地震の斷層が又四方にある此種の放射狀斷層上に繰返されたのであつた。此等はかゝる構造の地帶には地震の頻發する可能性を十二分に敎えて居るのである。

昭和二年三月七日奥丹後地方に起つた烈震も亦此種の運動にして、奥丹後半島の斷層地塊が傾動をなした爲に起つたのであつた。即ち在來の放射狀斷層谷に沿うて山田斷層が生じ共心圓狀斷層に沿うて鄕村斷層が生じたのである。

鄕村斷層は半島を西北より東南に横斷する峯山網野地溝の西南側を限る舊斷崖下に沿うて現はれ、淺茂川、磯間の海岸より、三重の西に至る迄一八粁の間北北西より南南東に走つた新斷層であつて、相對的に云つて、此斷層の西南側の地塊が東南に二・六米の横辷りをなし、〇・七米の隆起をなして居る。此斷層は一本の斷層線でなくして、五本の互に雁行せる小斷層群よりなつて居る。

山田斷層は半島の東南邊を限る舊斷層崖に沿うて現はれ、幾地より男山に至るまで七・五粁の間較〻西南より東北に走つた新斷層であつて、此斷層線を境としてその西北側の地塊は相對的に〇・五粁の隆起をなし、且北西に〇・四米の横辷りを行つた。

かゝる奥丹後半島の地塊運動は三月七日の大震によつて直ちに沈靜に歸したのでなくして、その後も屢餘震を繰返して次第に落着きつゝあることは其地塊の垂直的水平的移動が地震後に行はれた陸地測量部の三角測量及び水準測量、並びに其の後數ケ月に繰返して行はれたる測量によるも若干の變化をなしつゝあるによりても知ることができる。

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1. Introduction.

Japan has experienced several destructive earthquakes within a few years recently. The great Kwanto earthquake[1] of 1923, which has destroyed the most productive and populous regions with many cities and towns, with Tokyo and Yokohama at their head, was one of the most severe catastrophes, not surpassed by any others in our history. Then occurred the Tajima earthquake[2][3] of 1925 in Chugoku on the coast of the Sea of Japan, which was followed by another destructive earthquake in Tango,[4] the province next to Tajima, at 6 h. 27.6 p.m. on March 7 th. 1927. The most disturbed area of the last one is 25 km in diameter. The macroseismic wave was propagated through most parts of Japan, and the shock was well felt even by people in Tokyo, about 400 km distant from the epicenter. The damage was enormous, ranking next to that of the Kwanto earthquake. According to the official reports, 14,405 houses were entirely destroyed or burnt, and 2,908 persons fell victims of the shock. Economic losses were also tremendous, for the region was well konwn for its silk industry, especially as one of the principal places of the production of fine crêpes. The direct damages are estimated at more than 53 million yen. (Pl. XVII and Pl. XIX, Fig. A and B.)

Very conspicuously all those destructive earthquakes which recently occurred were accompanied by remarkable phenomena of the blocking movement. New faults were formed along old fault lines or rift valleys. Tilting of land-blocks took place along those lines of dislocation, as it has been well shown in some places by the change of the beach line. In the Kwanto earthquake those phenomena were exceedingly distinct, and in the Tajima and Oku-Tango earthquakes they were likewise remarkable. In the Tajima earthquake the new faults have been formed in a hill on the eastern coast of a cove called Tsuiyama-wan, which makes a typical rift embayment with a steep and straight

(1) Yamasaki. N., Physiographical Studies of the Great Earthquake of the Kwanto District, 1923. Journal of Fac. Sc. Imp. Univ. Tokyo, II, 2, 1926. pp. 77-119.

(2) Yamasaki. N., Tajima Earthquake (in Japanese), Report Eq. Invest. Com., No. 101, 1926, pp. 31-34.

(3) Kotô. B., The Tajima Earthquake of 1925. Journal of Fac. Sc. Imp. Univ. Tokyo. II, 1, 1926. pp. 1-75.

(4) A short remark on this earthquake, The Faults of the Tango Earthquake of 1927, by the authors is given in the Proceedings of Imp. Academy, III (1927), No. 4.

fault scarp coast on its sides. In the recent Oku-Tango earthquake two distinct faults of extensive length have been formed in the Peninsula of the same name, accompanying a considerable tilting of land-blocks of large areas along those fault lines. Now before going on with further explanations of those crustal movements, let us for a while look at the general features of the seismic district and its environs.

2. General Topography of the Earthquake District and its Environs.

Honshu or the main island of Japan makes a central pendant of the festoon islands in the western shore of the Pacific Ocean. Compressed southeastwards during its formation, the island makes a large crescent shape and

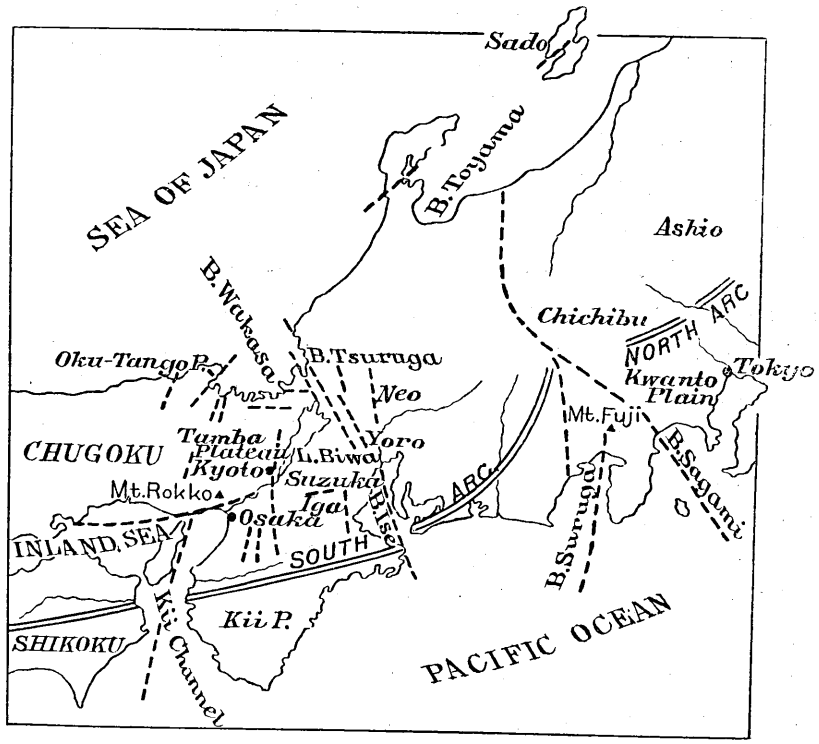


Fig. 1. Principal trends of mountain arcs and fault lines of Central Honshu. (Itoigawa Shizuoka Line in Central Japan, after H. YABE)

turns its convex or outer side to the ocean. The island, however, is not a single arc, but it is composed of two different arcs of large mountain systems, namely northern and southern arcs, which come together in the centre of the

island, where the curvature of arcs become greatest. The structural and topographical features are naturally very complicated in this apex of the island. There are two large notches of embayments with a great depth cut far into the land, namely the bays of Sagami and Suruga. A large depression of the low plain of Kwanto extends also inlandwards cutting the mountains of the northern arc into some separate blocks such as Ashio, Chichibu, Tanzawa etc. There are other blocks and rift depressions of various forms and sizes, and successive occurrences of earthquakes of different intensities are nothing but the constant reccurrences of blocking movements of unstable earthcrust of this district. In the eastern wing of the southern arc there are another two large notches of embayment of the same kind, Ise-no-umi, or the Bay of Ise in the east and the Kii channel in the west. Besides those depressions in the Pacific side, there is the remarkable embayment of Wakasa in the coast of the Sea of Japan, a large depressed basin, which breaks not a little the general monotony of that coast. The distance between the head of a small bay of Tsuruga, a branch of the Bay of Wakasa in the north and that of the Bay of Ise in the south is only 88 km., which is the shortest width across the island and measures only one half of the distance between the shores of the open sea and ocean in this district. Moreover the land between those two bays has partly sunk in an extensive area, which collected water and made the Lake Biwa, the largest lake in Japan. Very much like the structure of the Kwanto district in the east, these regions with the Lake Biwa in their centre are intersected by many fault lines and are composed of a mosaic of upheaved or depressed blocks of various size. There are two types of those fault lines, which run in two ways, one in longitudinal and the other in transverse to the general trend of the mountain axis of the southern arc. The former belongs to the system of the depression zone of Seto-uchi or the Inland Sea. The Bay of Osaka and the plain of the same name in the east end of that zone are bordered sharply by a fault line, which makes a straight fault scarp along the southern flank of the mountains of Maya and Rokko near Kobe and that of the extensive plateau of Tamba. The Iga fault scarp to the north of the Ueno basin farther east and the Kumakawa scarp, along which the northeast end of the Tamba plateau sinks abruptly to the coast of the Bay of Wakasa, are also typical examples of this category. On the other hand the transverse faults, which have the tendency to run at right angles to the trend of the arc, take the

radial course to the Pacific shore in the convex side of the arc, or converge near the Bay of Wakasa in the concave side. So in the district to the west of the Lake Biwa they run N.—S., forming the *horst* mountains of Hira-Hiei and Ikoma-Kongo and the depression plains of Yamashiro and Yamato between them, while in the region to the east of the lake one of those fault lines makes a considerable rift zone, running obliquely in the direction of N.N.W.—S.S.E. from the deep bay of Tsuruga to the Bay of Ise. Beside this great rift there are many other faults of various magnitude, especially in the northern shore of the Lake Biwa. These faults may be classified as the active and the dead as usual, where the former is defined as post-terrace faulting.

Before going into the main stage of the recent destructive earthquake in the shore of the Bay of Wakasa, let us glance for a while on the topography near the Bay of Ise. The Suzuka range, a divide between the both depressions of the Bay of Ise and the Lake Biwa, is a remarkable *horst* mountain with a steep fault line scrap to the east. The Yoro range, which runs parallel to the east of the former, is likewise a typical tilted block mountain. Its fault scarp dips steep and straight to the low plain of Mino in its eastern foot, and though it is eventually dissected by young valleys the original plane of the scarp may be distinctly traced by the remaining facets. The back slope of this tilted range makes a valley of a fault angle depression with the fault scarp of the Suzuka range, which is drained by the River Machiya. To the north, both the ranges of Yoro and Suzuka terminate at the Sekigahara gap, which joins the Biwa basin with the Mino plain and offers the passage for the trunk line of the Tokyo-Kobe railway. Direct to the northern side of this gap stand the mountain masses of Ibuki and Ikeda. The east side of the latter is truncated by a fault scarp, which descends abruptly to the flat plain of Mino in the direction S.—N. Mount Akasaka, well-known for its marble with many leading Permo-Carboniferous fossils of Japan, is located in the southeast end of the Ikeda mountain mass, and its steep cliff standing on the plain is a part of above mentioned scarp. This fault extends farther into the mountain to the north of the plain and makes a valley, along which the upper course of the River Ibi flows. There is another example of characteristic dislocation valleys in this mountain district. To the east of the valley of Ibi and parallel to it there is the famous Neo valley, where is an active fault of considerable length and height of the great earthquake of Mino-Owari in 1891. This rift is

nothing but the northern extension of the axis of the great depression of the Bay of Ise.

An intimate relation between topographical forms and earthquakes is well explained by these districts. Dr. Imamura[1] gave several examples of earthquake which occurred in the first decade of this century, among which that of Komono in 1903 was strongest. The epicenters of those earthquakes were migrating in a certain direction, or along the axis of the fault angle depression between two blocks of Suzuka and Yoro. The extension of this axial line in the direction of N. 30° W. runs along the west side of the Mount Ibuki, where several earthquakes were experienced in recent years, especially the earthquake of Anegawa district of 1909 which was the severest. The Anegawa earthquake was not accompanied by any new fault, but Dr. Kotô[2] considered an epicentric zone nearly parallel to the Asai fault in the northern foot of the Mount Ibuki.

Now let us turn our eyes to the districts along the Bay of Wakasa. This is one of the two large embayments of the Sea of Japan, and breaks not a little the general monotomy of that coast. Nearly semicircular in its form it measures about 70 km. E.—W. in diameter and penetrates 40 km. long into the land. Its shore is crenelleted again with many coves and peninsulas, and these afford every evidence of subsidence of the land in this region. Even any trace of a coast terrace, which is common along the sea shore out of the bay, is not found here. Very conspicuous is the development of faults in the land around the bay. As it has been mentioned already those faults run in radial and concentric lines in regard to the Bay of Wakasa. To the east, the bay is bordered by a considerable fault coast 15 km. long running N.W.—S.E., from the Cape Karei to the mouth of a small bay of Tsuruga. The Sazae peninsula on the west side of the Bay of Tsuruga is surrounded similarly by steep fault coast. Especially across the northeast end of the peninsula three faults of the radial type are well developed and the land blocks between them are upheaved or submerged, making the typical *horst* of the Cape Tateishi and the rift cove of Urasoko. The Bay of Tsuruga is nothing but a characteristic rift embayment depressed between those fault coasts on both sides.

(1) A. Imamura, Anegawa Earthquake of 1909 (in Japanese), Report Eq. Invest. Com., 70, 1910. pp. 36-38.

(2) B. Kotô, Ko-no Earthquake from the geological point of view (in Japanese) Report Eq. Invest. Com., 69, 1910. pp. 1-17.

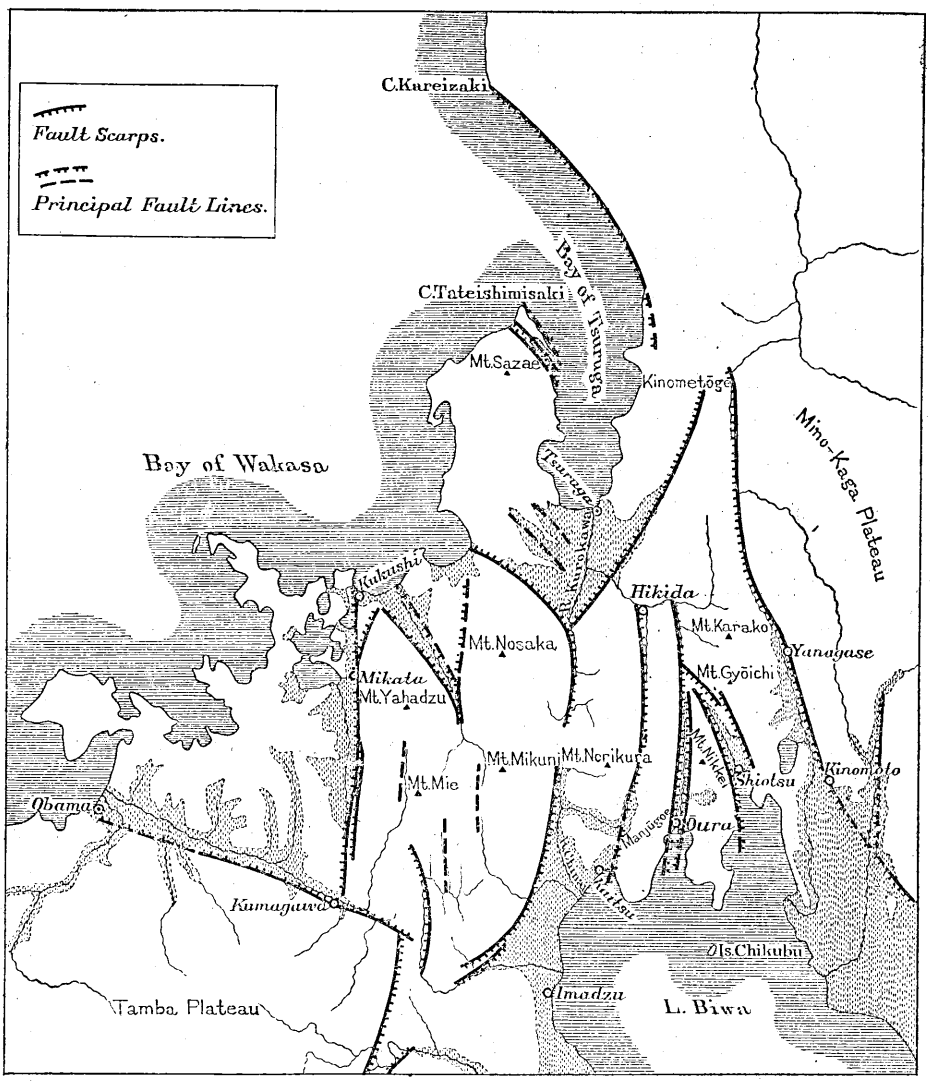


Fig. 2. The Geomorphologic fault structure of the districts between the Bay of Wakasa and the Lake Biwa.

On the other hand there is a large peninsula of Oku-Tango, which projects to the west of the Bay of Wakasa and was the stage of the most destructive catastrophe of 1927. This peninsula is semielliptical in form, measuring in its minor axis and semimajor axis about 40 km. Its ground consists of granite. Volcanic activity took place since the Tertiary period. Most of the Tertiary strata are tufaceous, through which volcanic rocks of later eruptions are ex-

posed in various forms, often as dykes as seen in the sea coast. There is no extensive plain beside some stripes of young alluvial plains along the principal streams. Sand-dunes are developed here and there on the north-western coast. The old landmass of granite and other material has been worn already to the nearly levelled height of 5–600 m, and having no prominent peaks it makes a plateau landscape, which is a characteristic feature of the Chugoku district in southwest Japan. The coast line is less indented, especially in the shore of the Bay of Wakasa, where a fault coast between a small cove of Ine and the mouth of the River Kurahashi makes a straight shore line. The monotony of this coast is broken merely by a sandspitz of three kilometers long and clad with evergreen pine forests, from which it is well known under the name of Amano-hashidate or "Heaven's bridge," and as one of the trio of the finest beauty spots of Japan. The lagoon embraced by this sandspitz is called Yosa-no-umi or Bay of Yosa, where the River Kurahashi flows into it. The fault scarp on the shore of those bays extends further inlandwards and then bifocates in the scarps on the left bank of the River Kurahashi and its tributary from the west. Another small but very distinct rift valley of Miye runs parallel in the west of the former. So the granite ridge between both valleys makes a simple and typical *horst*. The valleys of the Rivers Miyadzu and Okumo and the deep indented bay of Maidzuru in the southwest coast of the Bay of Wakasa are considered to be formed along the rifts of the radial type.

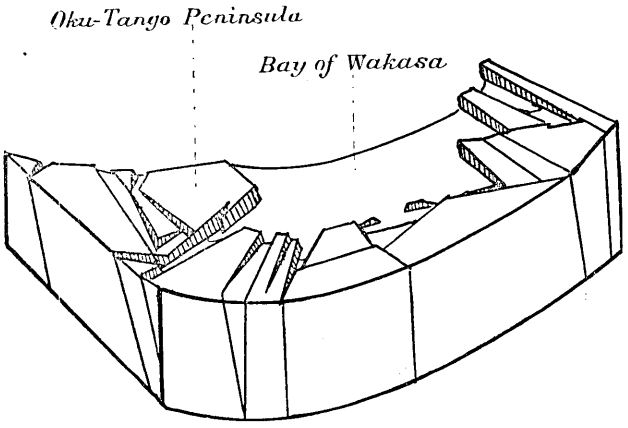


Fig. 3. Diagrammatic block of the districts along the Bay of Wakasa.

The Oku-Tango Peninsula is traversed also by some faults of the concentric type. One of them makes the rift valleys of the Rivers Takano and Fukuda in a line, where many towns and villages with their flourishing silk industry are located. Another fault of the same type runs through the cnetre of the peninsula, and makes a gap between the mountains with the height of 5–600 meters and the hills of 2–300 meters in altitude.

As a result of the recent blocking movement two distinct seismic faults have been formed on this peninsula, which are called the Gômura and the Yamada fault respectively, named after the villages, where they are well developed. Following is the detailed descriptions of those faults. (Pl. XVIII).

3. Terrestrial Disturbances.

a. *The Gômura Fault.*

General remarks: Across the neck of the Oku-Tango peninsula there is a remarkable rift valley of Amino-Mineyama of the concentric type. The fault scarp along the southwest side of this valley makes step faults and is well dissected by the young stage of erosion. Along each one of these steps the following five new seismic faults or rifts have been formed in the recent earthquake, as shown in Pl. XVIII.

a) *The Takahashi rift.* This rift starts at the sea shore between Asamogawa and Iso, and runs in the direction of S. 30° E. to Santanda, where it turns gradually to S. 15° E. until it reaches Yasu, with a total length of 8.9 kilometers.

b) *The Nimbari rift.* It starts 500 m east of the south end of the Takahashi rift. Passing through the village of Nimbari it runs from N. 8° E. to S. 8° W. until it disappears in hills to the south of Sangenya. Total length measures 2.4 km.

c) *The Nagaoka rift.* It may be traced 3.75 km long from half a kilometer east of the south end of the Nimbari rift to Taro-dani in the village Kuchi Ono in the direction N. 30° W.—S. 30° E.

d) *The Mie rift.* It appears in the west end of the village of Mie to the southeast of the Nagaoka rift. It is not so long as the others, measuring only 0.3 km in length and runs N.60°W.—S.60°E.

These four rifts are not arranged in a line, but in such a manner as the south end of each rift terminates some distance west of the north end of the next rift, making a typical form of échelon arrangements.

e) *The Sugitani rift.* Isolated from the above mentioned échelon this rift begins to the north of the town of Mineyama and runs to Sugitani 0.9 km long in trend of S.66°E.

Those five rifts make all together a grave fault zone from the shore of

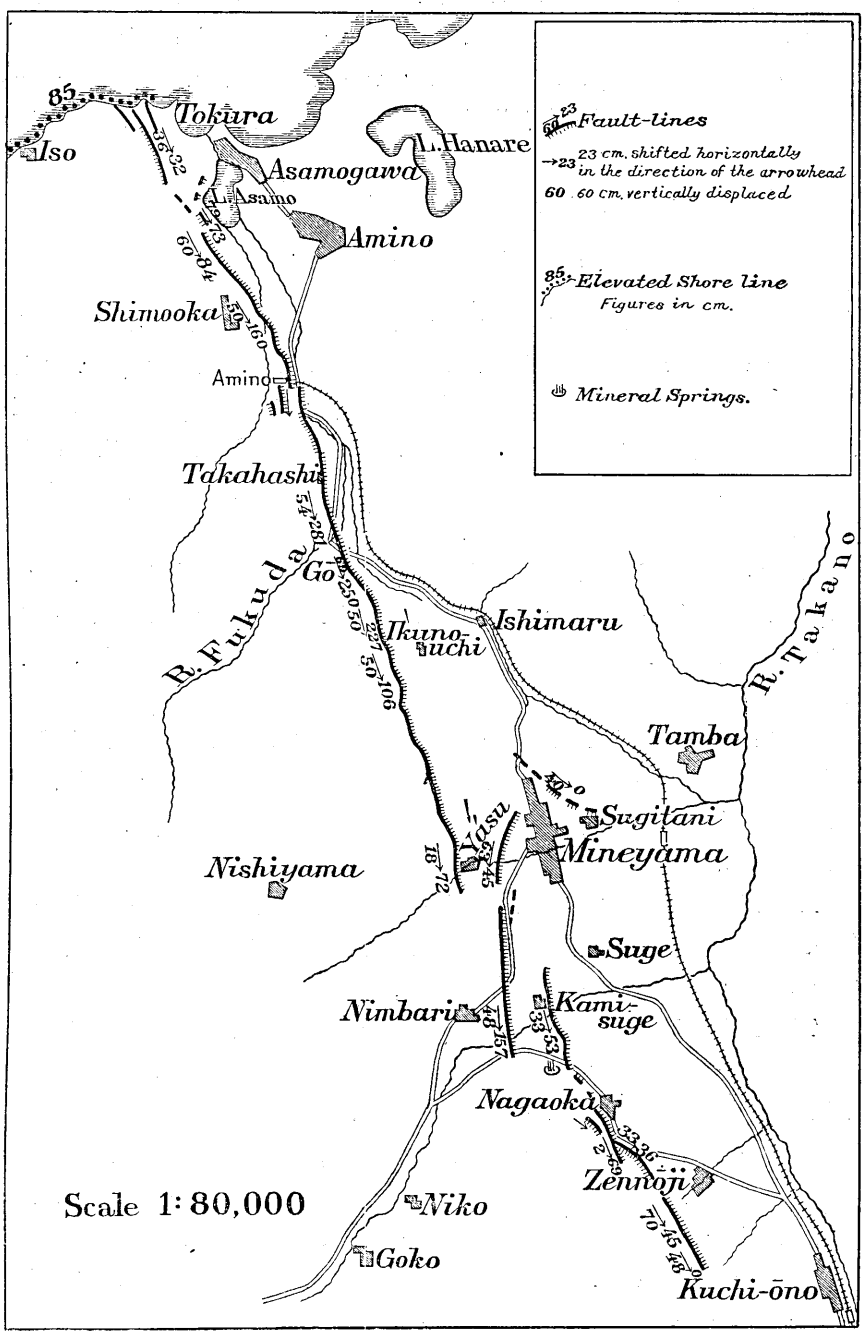


Fig. 4. The vertical and horizontal displacements of the land to the west of each rift of the Gômura fault.

the Sea of Japan near Asamogawa inlandwards to the west end of Mie-mura nearly 18 km long in the direction N.30°W.—S.30°E. This fault zone will be called Gômura fault zone in general or simply Gômura fault, named after the village where it was first discovered and where the amount of displacement is greatest. The land block to the southwest of the fault has been elevated and shifted relatively southeastwards when referred to that of the other side of the fault. The amount of displacement of land along fault lines is well measured on disjunct roads, bridges, fences, walls and other such things. The greatest horizontal displacement is 2.81 m at the center of the Takahashi rift in the village of Gômura. This amount decreases farther north or southwards, and becomes 0.32 m in its north end on the sea shore, and 0.72 m at the south end. The horizontal displacement of the Nimbari and Nagaoka rift is 1.57 m and 0.53 m respectively, where the latter becomes gradually less until there is no marked displacement at Kuchi-Ono. That of the Mie rift is 0.3m, while no shifting is observed at the Sugitani rift.

The vertical displacement is less than the former with the maximum amount of 0.79 m, and is much influenced by the original features of the land. Generally the land block in the southwest side of faults is elevated, with an exception of the Takahashi rift, along which some tracts of land in Tokura-dani and its northern hills are depressed in the same side.

When a rift crosses low paddy lands or flat mountain valleys it makes generally a very distinct fault scarp. Sometimes it appears as mole tracks and sometimes makes a very gentle flexure of land surface. On the mountain slope, however, they form some sharp clefts, cutting deep into the ground, and arranged generally in échelon form. Among many rifts the most distinct and continuous one is the Takahashi rift, which runs through hills and plains with great displacement. On the other hand the Nimbari rift is continuous in flat lands but rather disjunctive in hills, while the Nagaoka rift is traceable only in plains. The Mie and Sugitani rifts are comparatively indistinct and discontinuous. Along many rifts and on the land block of their southwest side there is a zone of many tension clefts 0.5m–20m wide in échelon arrangement, which is however quite rare on the block of the northeast side. The damage of houses was also remarkable in the fault zone as well as on the northeast block.

Dr. Imamura has estimated the dip of the faults to be 70° to S.W. from

the fact that the epicenter of after-shocks are located always on the southwest side of the Gômura fault. The junior author of us has measured it to be 60°–80° to S.W. in the place where the Takahashi and Nimbari rift run across mountain spurs and valleys. He has determined also that the fault is a reversed fault. Now let us describe each fault more in detail.

a) *The Takahashi Rift.* This rift has most distinctly appeared near the village office of Gômura. It runs here through the alluvial plain of the River Fukuda in the direction S. 16° E. to N.16°W., making a huge mole track on paddy fields. Where it cut highways it makes very distinct horizontal and vertical displacement of 2.5 m and 0.69 m respectively (Pl. XX, XXI, XXII.). Tracing it northwards it penetrates in a hill and forms a group of clefts. In Shirutani the rift attains its maximum development. The main rift runs S.14°E.—N.14°W. and makes a fault scarp dipping to the east with some cleft on the scarp head. The displacement of the land measures here 2.81 m horizontally and 0.54 m vertically. On the east side of this rift there is only one cleft, while on the west side there are many open clefts side by side, one of which is 1.5m wide. The main rift extends farther northward through a terrace in the valley and the village of Takahashi in the direction of N.9°W., where the land in the west side of the fault is elevated 0.3 m and shifted 3 m southwards. Then the rift runs along the Amino highway, and where it met a hill spur end it turns its course to the outside of the hill, and when it met a valley end it deflects to the valley head.

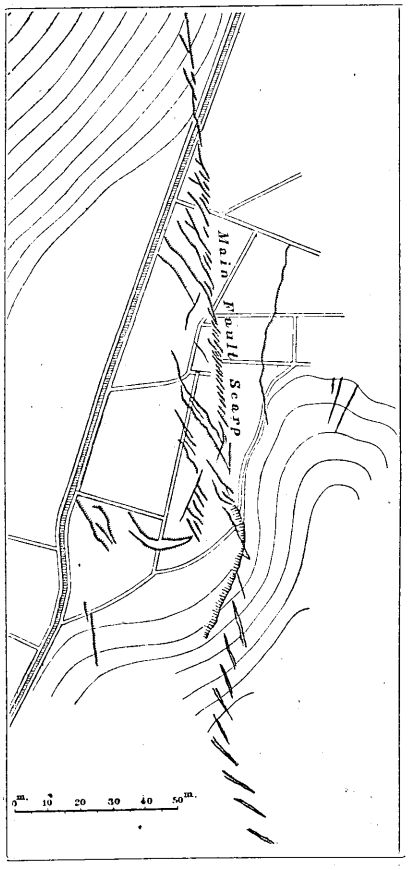


Fig. 5. Shirutani valley, Gômura, showing clefts in échelon arrangement on the land block to the southwest of the main fault.

An alluvial lowland to the north of Amino railway station, through which

the River Fukuda flows into the lagoon of Asamogawa, is a typical rift valley, walled very distinctly by an old fault scarp of Takaten-yama hill to the west. Two small rocky mounds Otoko-Benten and Onna-Benten near the shore of the lagoon are nothing but the isolated blocks detached from the said hill.

The Takahashi rift runs through this low land. Instead of a crack or fracture it makes here sometimes a wavy swelling of ground. The level plane of paddy fields is tilted very gently, leaving a part of their rectangular surface uplifted and dry, while the other parts were depressed and have collected water. (Pl. XXIII and Pl. XXIV, Fig. A.). More exactly these swellings are formed by the alternate occurrence of two kinds of flexure, one with the trend of N.—S. and the other S.35°E.—N.35°W. A land block to the west of the fault is elevated 0.6 m and shifted 1.6 m to the southeast in the south end of the low land. These amounts however diminish gradually as we proceed northward. Near the rock mound Otoko-Benten the surface of land exhibits an interesting disturbance forming a very complicated combination of fault and flexure (Pl. XXIV, Fig. B.). Unusually here the west side of the fault is depressed 0.79 m lower and the mound of Otoko-Benten become tilted northwards. A branch of the rift runs along the foot of the old scarp deforming paddy fields to a marshy depression, while the main fault cuts through the western hill and reappears in the valley of Tokura taking a course of S.35°E.—N.35°W., where the western side of the rift is depressed 0.36 m and shifted 0.32 m to the southeast (Pl. XXV.). On the sea shore the rift makes a huge cleft cutting deep into the layer of volcanic agglomerate and tuff on the precipitous bluff. Two subordinate rifts are formed also on the shore parallel

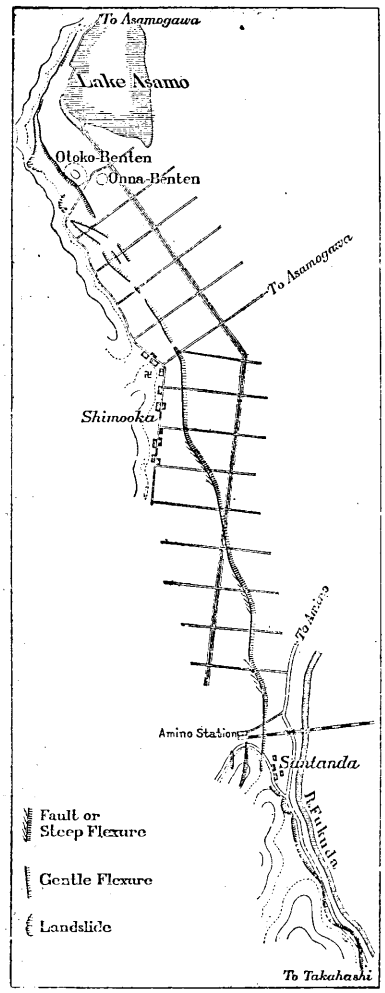


Fig. 6. The Takahashi rift between the Lake Asamo and the railway station Amino.

to, and some hundred meters apart from, the main fault (Pl. XXVI, Fig. A.).

Another subordinate rift has been observed to the west of Amino railway station. It is traced some 150 m long on a hill to the south of a shrine called Santanda, where the land in the west side of the fault is upheaved 0.3 m and moved horizontally 0.4 m to the south.

Now let us come back to Gômura and trace the main Takahashi rift to the south in the oposite direction. The rift, which is well developed in the alluvial plain of the River Fukuda, runs to the southeast and penetrates into hills. It passes indifferently through the spurs and valleys as Nagamachi-dani, Kojiki-dani, Hoso-dani, Kishiga-tani, and Yamauchi-dani. Then appearing in Otani of Ikunouchi, it turns along the north foot of Goyama. Then it reappears in Morikae but crossing a valley called Minami-no-Yasutani it disappears in the hill on the other side of the valley. The total length of the Takahashi rift from the sea shore to here is 8.9 km. When the rifts occur in valleys they make generally mole tracks, while on the hill side they form a group of cracks of échelon arrangement. Tension cracks in that arrangement are common along the rift and especially on the land block of its west side, but instead of cracks some elongated elliptical domes in the same arrangement in direction N.W.—S.E. were found in Kojiki-dani. Vertical and horizontal displacements are 0.5 m and 2.27 m in Kishigatani, 0.5 m and 1.06 m in Otani, Ikunouchi, and 0.18 m and 0.72 in Yasu respectively.

One of the most significant phenomena along the rift, which was never experienced in any other great earthquake of this country, was the occurrence of a remarkable slickenside of the fault plane of granite, through which the main fault pierces deep into the ground. It occurred in the south end of the villages of Ikunouchi and Hosotani. In the former the fault plane strikes N.19°W.—S.19°E. and dips 80° to N.N.E., The slicken striations run obliquely from S.E. up to N.W. down, and this shows that the land block on the southwest side was slipped up in the direction of southeast (Pl. XXVII, Fig. A and B.). The slickenside which occurred in Iwatani, trends N.10°W.—S.10°E. and dips 65° to W.S.W., showing that the fault is reversed. These trends and dips are however merely local cases, and they do not refer to those of the Takahashi rift in general.

Between Gômura and Yasu the rift makes a zigzag course. So in Kishigatani a mole track rift runs from N.20°W. to S.20°E., then coming on a

spur to the west of that valley, it makes a group of cracks which tend S.45°E. When it comes down to the next valley it strikes S.25°E. and then S.20°E. in Yamanouchi-dani. The fact shows that this rift is a reversed fault dipping 60°–80° to S.W.

b) *The Nimbari Rift.* As it has been mentioned before, the west scarp of the Amino-Mineyama depression zone makes a step fault and the Takahashi rift, which has been just described, is formed on its first step as it is well explained by the land features of this district (Pl. XXVI, Fig. B.).

Running to the east of this rift there is another old fault, which is well indicated by the presence of a dislocation valley and some detatched hills cut-off by that valley. A part of the Kumihama highway, between Mineyama and Nimbari, as well as the new Nimbari rift of the recent earthquake are found in this valley.

The Nimbari rift is distinctly developed in Yasutani and Nimbaridani. In the former case the rift starts at the compound of a school of technology in the west end of a town of Mineyama and runs across the Yasutani valley with the trend of S.12°W. In the centre of the valley it turns to the south until it reaches a temple of Dizo in Kujo. Then cutting through the spurs and valleys of a mountain to the west of Kumihama highway it gets in the east end of the village of Nimbari, extending further south to the hill in the opposite side of Nimbari valley.

On the other hand, to the north of the school the rift turns to N.E. and extends to a church yard of Myokoji crossing through small valleys Sakinoye, Myoki and Nagaya. This rift occurs as mole tracks or flexures, when it passes through flat lands as usual, but is very insignificant on the flank of spurs. The horizontal and vertical displacement of the west block is 0.45 m and 0.63 m in Yasu and 0.48 m and 1.57 m in Nimbari respectively. This fault line, as the former, turns its convex side to the east on the spurs and to the west in the low valley floors, and the fact shows that the fault plane is dipped to the west.

c) *The Nagaoka Rift.* This rift is more discontinous and insignificant than the Nimbari rift. It appears merely as a gentle flexure on the surface of cultivated flat land. It extends from Sannodani near Suge through the villages of Kamisuge and Kanada and around the eastern foot of a hill covered with mulberry trees to a highway Kuchiono-Kumihama, where very remarkably

a mineral spring begun to spout out of a crack. In Kamisuge the land block in the west side of the fault elevated vertically 0.33 m and moved horizontally 0.53 m to the southeast. The rift disappeared here for a short distance, but it reappears in the southwest of a small village of Nagaoka and proceeds to the valley of Danno-odani making 0.36 m vertical and 0.69 m horizontal displacement. The main rift is crossed here obliquely by another rift which runs N.46°W.—S.46°E. and falls 0.3 to the southwest side. So the land blocks between both rifts make a small *horst* and *graben* in northern and southern sides of the crossing point of the rifts.

The Nagaoka rift disappears and reappears again to the west of Zennoji and passing through small valleys of Okutani, Kotani, Kuritadani etc. it extends to Tarodani in Kuchi-Ono, with its whole length 3.75 km from Sannodani to this destination.

d) *The Mie Rift.* Dr. Imamura discovered a rift along a railway curve in the west end of the Mie village. It runs across the railway from west to east making a heavy disturbance and cracks on the surface of paddy fields nearby, with the trend N.60°W.—S.60°E. Its length is not so long as the others, measuring only 0.25 km. The land block to the west of the fault was elevated 0.4 m and shifted horizontally 0.3 m to S.E.

e) *The Sugitani Rift.* It appears on the hills to the north of the town of Mineyama, running across the small valleys such as Dogoya, Kosaka, Nishigai, Nishi, etc. and spurs lying between them with the trend of N.66°W.—S.66°E. The displacement of land is smaller than that of other four rifts. It measures only 0.4 m's depression of the southwestern block, and no horizontal shifting. Though the cracks on the hills to the northeast of Mineyama school and those in the compound of Mineyama court are taken as the northern extension of this rift, the whole length is scarcely 0.9 km.

b. *The Yamada Fault.*

The Yamada fault is found just along an old fault scarp in the southeastern side of the Oku-Tango Peninsula (Pl. XXVIII.). Its general trend is S.55°W. to N.55°E. In the village of Yamada the fault appears across a highway and cultivated lands forming a remarkable flexure instead of a steep rift (Pl. XXIX, Fig. A.). It seems that the land in the southeastern side of the fault has been depressed and shifted to the southwest, with the vertical and horizontal

displacements of 0.7 meter and 0.8 meters respectively. The fault, however, makes a fracture cut deep into granite, which forms the ground rock and is exposed near the entrance of a railway tunnel on a hill called Shiro-yama by the side of a highway (Pl. XXIX, Fig. B.). Many other huge cracks have been formed on the flank of the hill. The main fault extends then northeastwards along the railway and the bank of the River Kurahashi, manifesting various forms of disturbance, until it reaches the shore of the Bay of Yosa. The paddy fields in the villages of Iwataki and Otokoyama are traversed by several cracks, which run in the direction of the fault. Many small sand cones are formed along those cracks. Very remarkably some tracts of land in the southeastern side of the fault in Otokoyama are partly submerged into the bay (Pl. XXX, Fig. A.). A new hot spring made its appearence also near the fault in the village of Yumiki.

On the other hand the southern extension of the Yamada fault passed through the village of that name crushing all houses and cottages into pieces and reappears in the mulberry fields in the west end of the village, where it makes many large rifts (Pl. XXX, Fig. B. and Pl. XXXI.). Further westsouthwestwards it extends to a large village of Ichiba, which was totally destroyed by shock and fire. The total length of this fault measures 7.5 km.

c. *The Tilting of Land, etc.*

The significance of tilting up of the land block is well made out, not only by this apparent elevation along the fault line, but also by the emergence of the beach line along the shore of the Sea of Japan in the west of the fishing village of Iso. The maximum amount of the absolute elevation measures 0.8 m in Hamazume. Such instances may be traced for far remote ages, and there are some evidences that the Oku-Tango Peninsula has undergone a general tilting. According to the personal observation of the junior author there is a good development of coast terraces along the coast of the Sea of Japan. It is most remarkable on the northeast coast of the peninsula with the maximum height 80 meters above the sea level. The height decreases gradually from the northernmost Cape Kyo-ga-misaki down to the southwest until it measures 20m and 10 m near by the Bay of Kumihama. No trace of terraces occurs on the fault coast of the peninsula along the Bay of Wakasa. So generally, the peninsula has been tilted up on its northern part and down to the south long

before the recent disturbance.

The Land Survey Department of the Imperial Army undertook the new levelling and triangulation survey with reference to the pre-earthquake survey. The survey was carried on at first during May and June. It was repeated from August to September, and then from October to November. The vertical displacement measured from the data obtained at the stations on both sides of the Yamada and Gômura faults in the first survey is 1.1378 m and 0.7491 m respectively. The land block in the west side of the Gômura fault moved horizontally to the south-southeast in general and 1.54 m in maximum. In the second survey the vertical displacement increased 5.6 mm., in the Gômura fault and 2.7 mm. in the Yamada fault, while the greatest horizontal displacement 0.324 m to north or nearly in the reversed direction in the block in the west side of the Gômura fault. But in the third survey it was found that the land moved 0.898 m once more to south. According to the results of the first and second surveys the peninsular part or the land block in the east of the Gômura fault has made northward displacement 1.077 m in maximum, while the third survey shows that the block has moved generally in reverse to southwest, with maximum displacement 0.336 m. It was found also in the second survey that the block in the southeast side of the Yamada fault shifted 0.398 m to north-by-west, while it has moved 0.146 m to southwest within two months until the time of the third survey. The facts show that the land moves not only by the greatest shock but also for all time, often accompanied by the subsequent minor after-shocks and it wants much time to settle in a stable state.

Among various disturbances which were accompanied by the earthquake, many landslips occurred in mountain districts, one of which, that happened in a sand dune near Amino is most remarkable. It took place on the eastern side of a dune which is nearly 70 m high and stands on the shore of a lagoon called the Lake Hanare. An immense volume of sand masses tumbled and slipped down into the shallow basin of the lagoon. Not only has it sunk deep into the lagoon, but also it has pushed up the layers of soft clay in the bottom of the lagoon upon the surface of the water, making a huge warping of mud some meters high (Pl. XXXII and XXXIII.).

Issues of new springs have been experienced in several places. Besides the thermal springs of Nagaoka along the Gômura fault and Yumiki along the

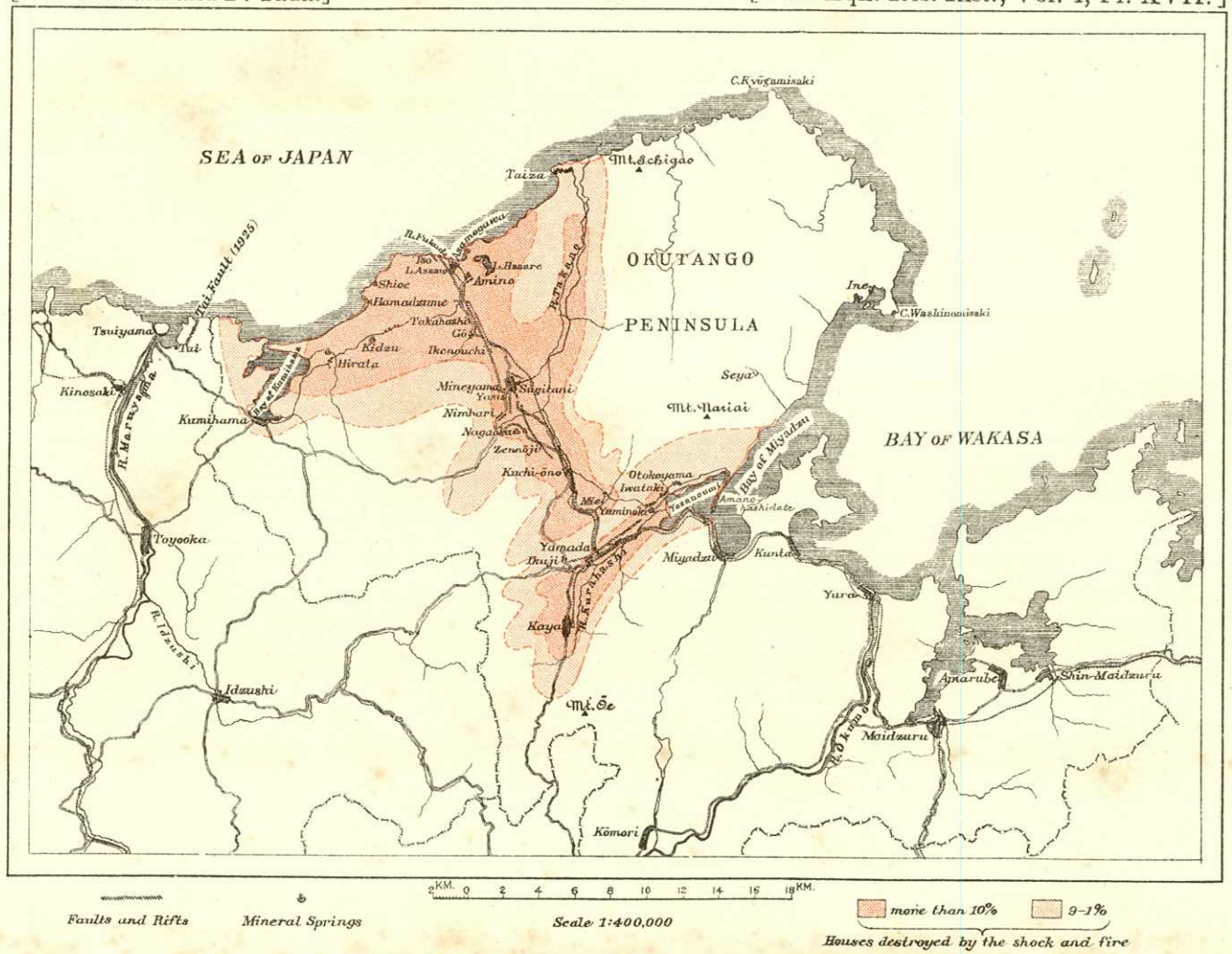
Yamada fault already mentioned those of the Kidzu spa in the fault valley to the west of Amino railway station have found new jets, and also the quantity of the spring has been enormously increased.

4. Résumé

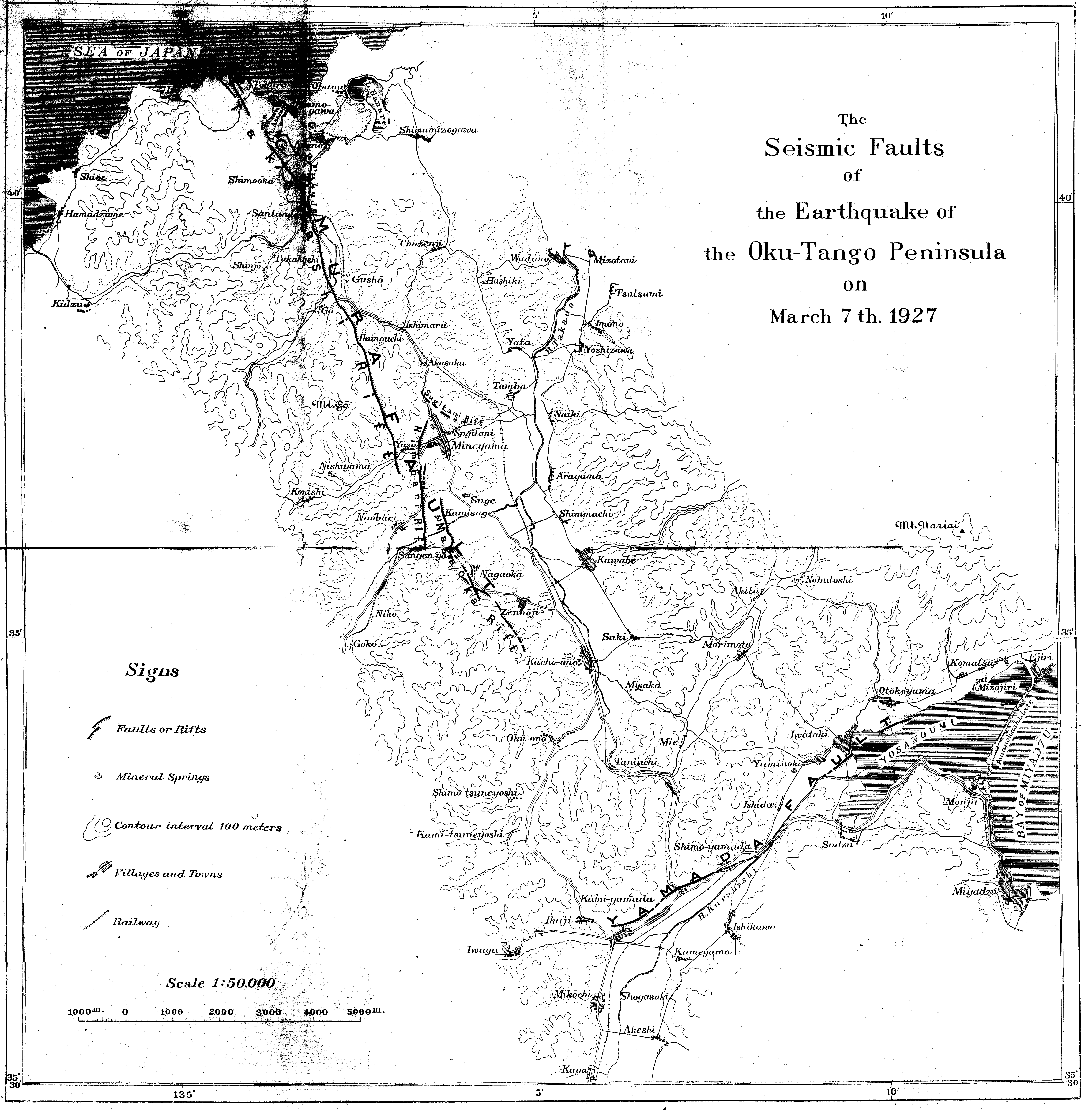
The Kinki district in the central part of Honshu or the Main Island of Japan is traversed by many fault lines, which run in radial and concentric directions with reference to the great depressed basin of the Bay of Wakasa, an indentation of the Sea of Japan, and it consists of a mosaic of land blocks of various forms and sizes, which are bordered by those fault lines. Very remarkably some of these faults are active, and many earthquakes were experienced along these lines of dislocation. Among them, those which occurred in the Neo rift valley and along a great fault between the bays of Tsuruga and Ise are most conspicuous. The recent destructive earthquake of Oku-Tango of March 7th., 1927 is nothing but the effect of the blocking movement, which was repeated in the old dislocated block of the Oku-Tango Peninsula on the west coast of the Bay of Wakasa. In this earth disturbance two remarkable faults were formed in accordance with old dislocation lines, namely the Gômura fault about 18 km long in a concentric direction and the Yamada fault 7.5 km long in a radial direction with reference to the bay. The peninsula did not moved as a single block, but some blocks bordered by those faults have undergone their respective movement, which accompanied the main and after-shocks of this great earthquake. The dislocated blocks did not become quite settled just after the main shock, but they were followed by some slight movements until they became settled in a stable state. The evidence was remarkably shown by the elaborate work of the Land Survey Department of the Imperial Army.

Meizoseismic Districts of the Oku-Tango Earthquake, 1927

[N. Yamasaki and F. Tada.] [Bull. Eqk. Res. Inst., Vol. 4, Pl. XVII.]



（震研彙報第四號、圖版、山崎、多田）


The
Seismic Faults
of
the Earthquake of
the Oku-Tango Peninsula
on
March 7 th. 1927
SEA OF JAPAN
Signs
Faults or Rifts
Mineral Springs
Contour interval 100 meters
Villages and Towns
Railway
Scale 1:50,000
1000m. 0 1000 2000 3000 4000 5000m.
YOSANOUMI
BAY OF MIYADZU
Mt. Nariai
Mt. Gō
Sugitani Rift
Mineyama
Kawabe
Miyadzu
Shimooka
Hamadzume
Kidzu
Takahashi
Shinjō
Gushō
Chūzenji
Wadano
Mizotani
Tsutsumi
Hashiki
Ishimaru
Ikunouchi
Akasaka
Yata
Imono
Yoshizawa
Tamba
Naiki
Sugitani
Yasu
Nishiyama
Konishi
Arayama
Suge
Kamisuge
Shimmachi
Nimbari
Nagaoka
Zenhōji
Niko
Goko
Suki
Akitō
Nobutoshi
Morimoto
Kuchi-ōno
Misaka
Komatsu
Ejiri
Mizojiri
Otokoyama
Iwataki
Yuminoki
Oku-ōno
Mie
Taniuchi
Shimo-tsuneyoshi
Ishida
Monjiu
Kami-tsuneyoshi
Shimo-yamada
Sudzu
Kami-yamada
Ikuji
Ishikawa
Iwaya
Kameyama
Mikōchi
Shōgasaki
Akeshi
Kaya
Shimamizogawa
Obama
YAMADA FAULT
GŌMURA FAULT
135°
35° 30'
35'
40'
5'
10'

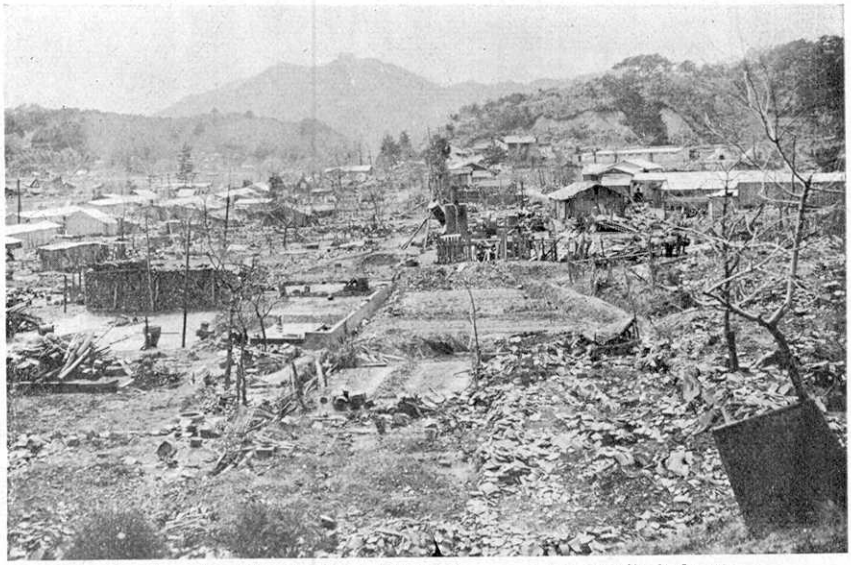


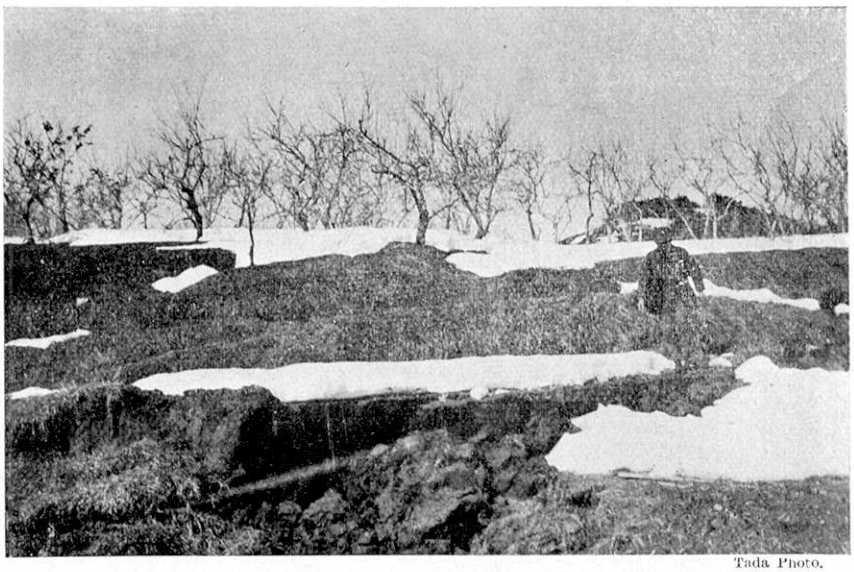
Fig. A. The town of Mineyama, a centre of silk industry, totally destroyed by the shock and fire. Some new booths in the picture were built after the quake.

Fig. B. The town of Amino, severely damaged by the earthquake and fire.

（震研彙報第四號、圖版、山崎、多田）

Yamasaki Photo.

Fig. A. The Takahashi rift, crossing a country road near the village office of Gômura. The land in the back upheaved 0.52 m and shifted leftwards 2.5 m.



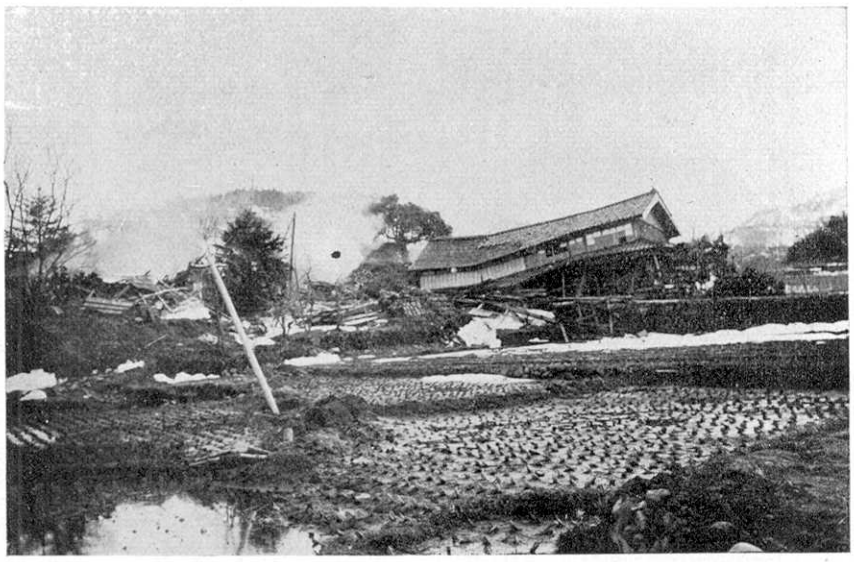
Tada Photo.

Fig. B. The Takahashi rift in a mulberry field in the village of Gômura.

（震研彙報第四號、圖版、山崎、多田）

Yamasaki Photo.

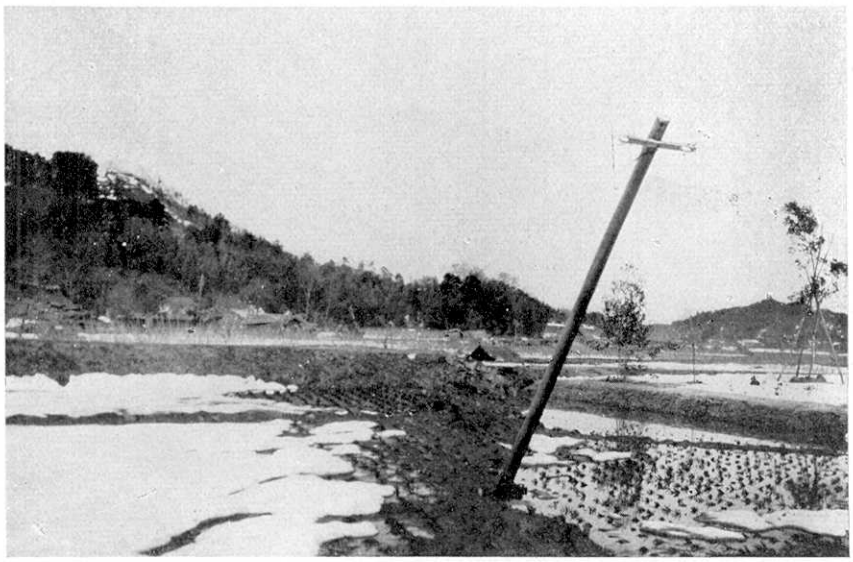
Fig. A. The Takahashi rift in the village of Gômura, crossing a road and making vertical displacement 0.69 m and horizontal shifting 2.5 m.



Yamasaki Photo.

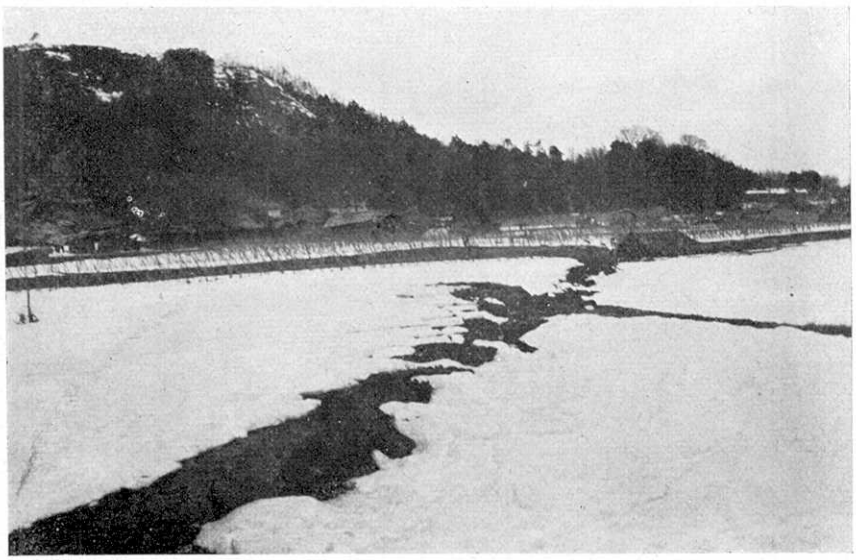
Fig. B. The Takahashi rift in Gômura. The rift runs from the front of the picture into the village in the back making mole tracks. The paddy field to the right of the rift upheaved.

（震研彙報第四號、圖版、山崎、多田）



Yamasaki Photo.

Fig. A. The Takahashi rift in the village of Gômu-a.
The land to the left considerably upheaved.



Tada Photo

Fig. B. The Takahashi rift in Gômura through the snow clad field making a step, a half metre high.

（震研彙報第四號、圖版、山崎、多田）

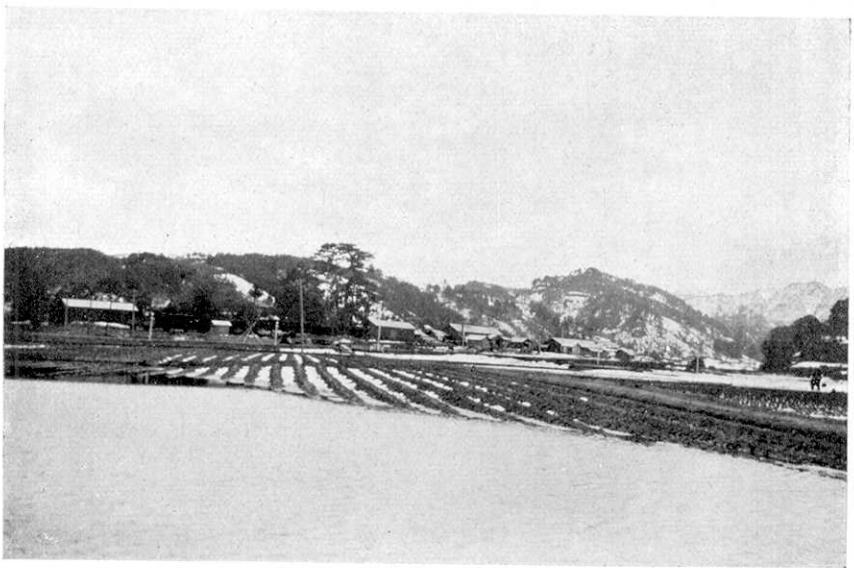
Yamasaki Photo.

Fig. A. The Takahashi rift near the railway station of Amino, making a wavy swelling of paddy fields and collecting water in its shallow depressions.

Yamasaki Photo.

Fig. B. Ditto.

（震研彙報第四號、圖版、山崎、多田）



Yamasaki Photo.

Fig. A. The Takahashi rift near the railway station of Amino. The paddy field partly depressed and collected water.

Yamasaki Photo.

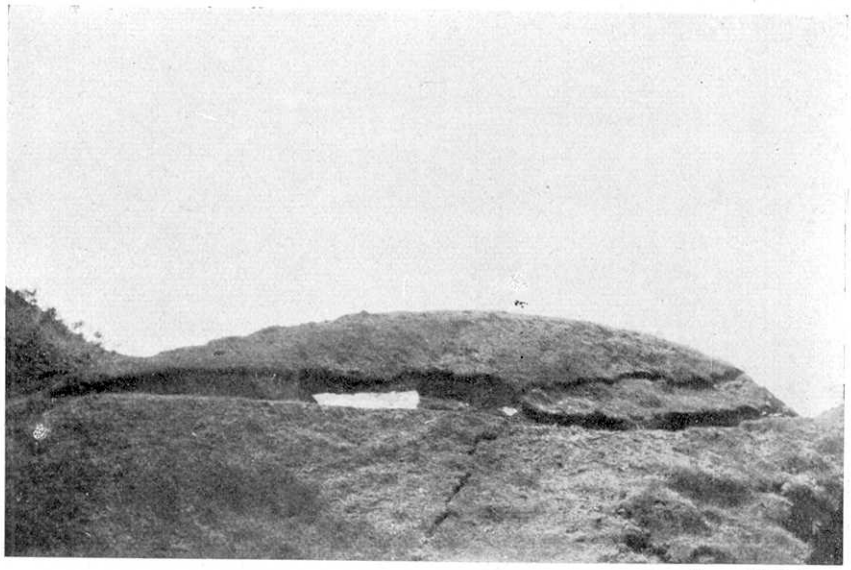
Fig. B. The Takahashi rift near Otoko-Benten. The surface of the even paddy field makes a complicated combination of faults and flexures.

（震研彙報第四號、圖版、山崎、多田）

Tada Photo.

Fig. A and B. The Takahashi rift crossing a hill in the northwest side of Tokura valley to the west of Asamogawa.

（震研彙報第四號、圖版、山崎、多田）



Yamasaki Photo.

Fig. A. The north end of the Gômura fault on the coast of the Sea of Japan. The fault is indicated by a huge cleft through the agglomerate bluff in the centre of the picture.

Tada Photo.

Fig. B. The Nimbari rift in the Gômura fault zone. The paddy fields to the left remarkably upheaved.

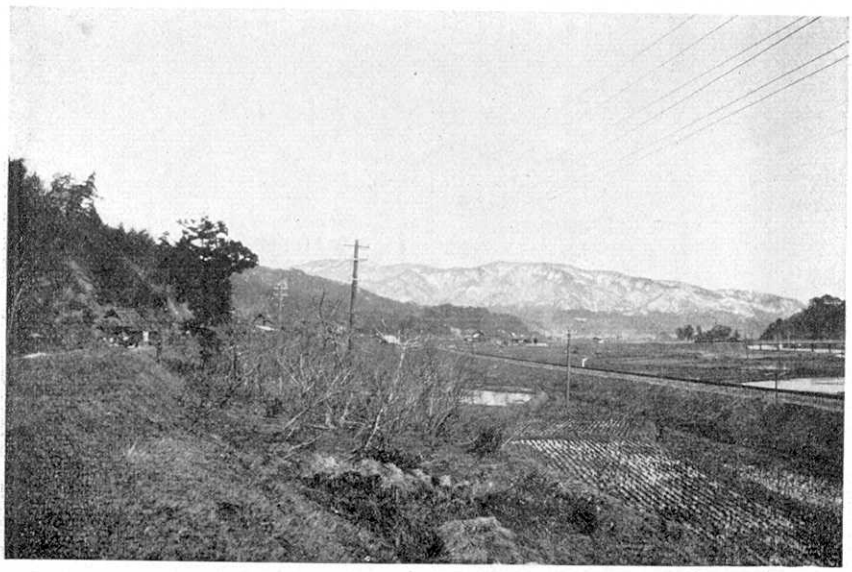
（震研彙報第四號、圖版、山崎、多田）

Tada Photo.

Fig. A. The Takahashi rift in Ikunouchi. A remarkable slickenside made by the fault plane in granite.

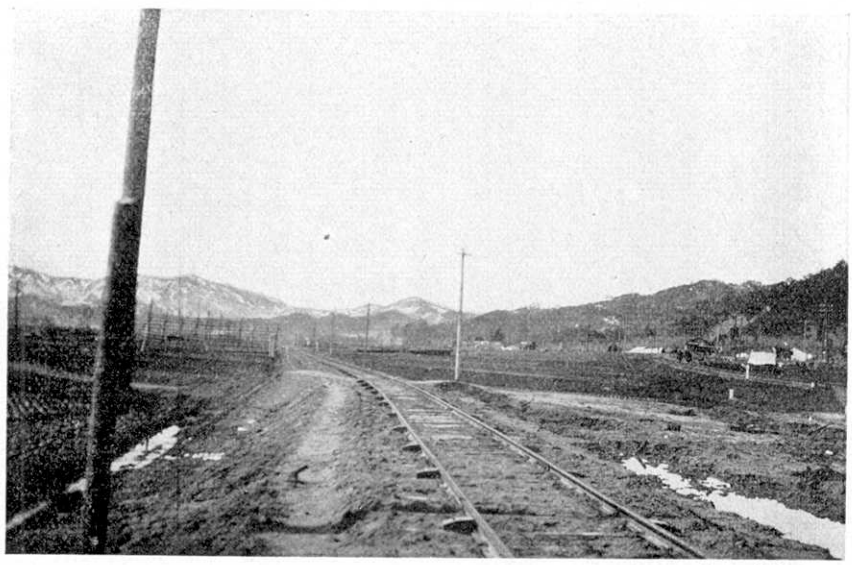
Fig. B. The Takahashi rift. A general view in Ikunouchi.

（震研彙報第四號、圖版、山崎、多田）



Yamasaki Photo.

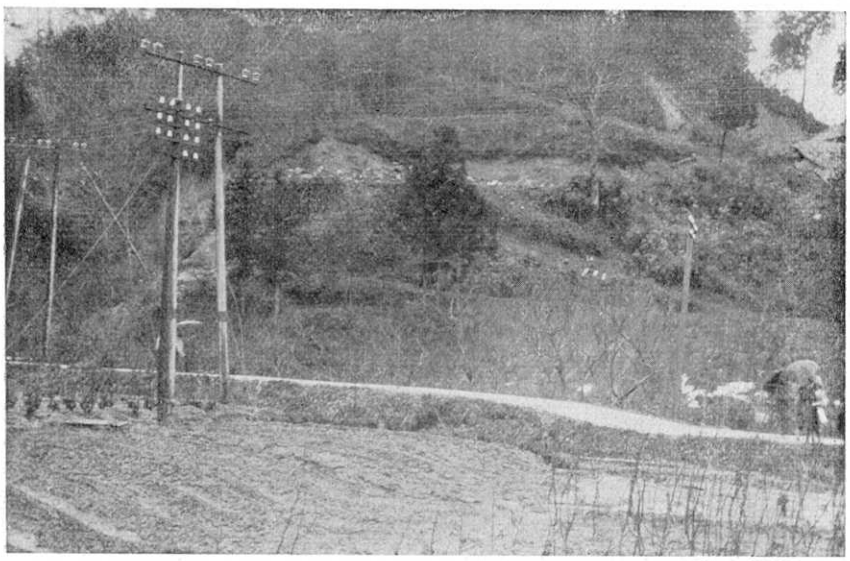
Fig. A. The valley of the River Kurahashi, along which the new Yamada fault is formed.



Yamasaki Photo.

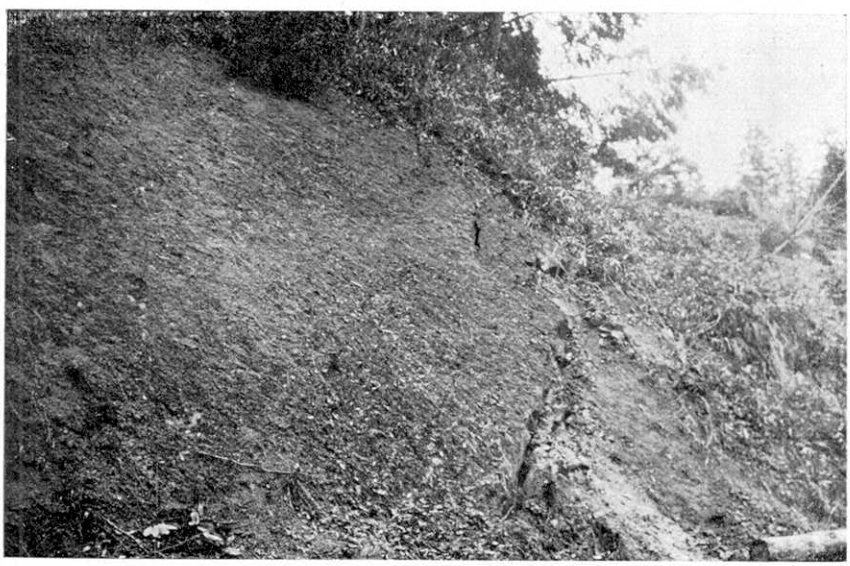
Fig. B. The Yamada fault is formed along the foot of the granite hills, an old fault scarp to the right of the picture.

（震研彙報第四號、圖版、山崎、多田）



Yamasaki Photo.

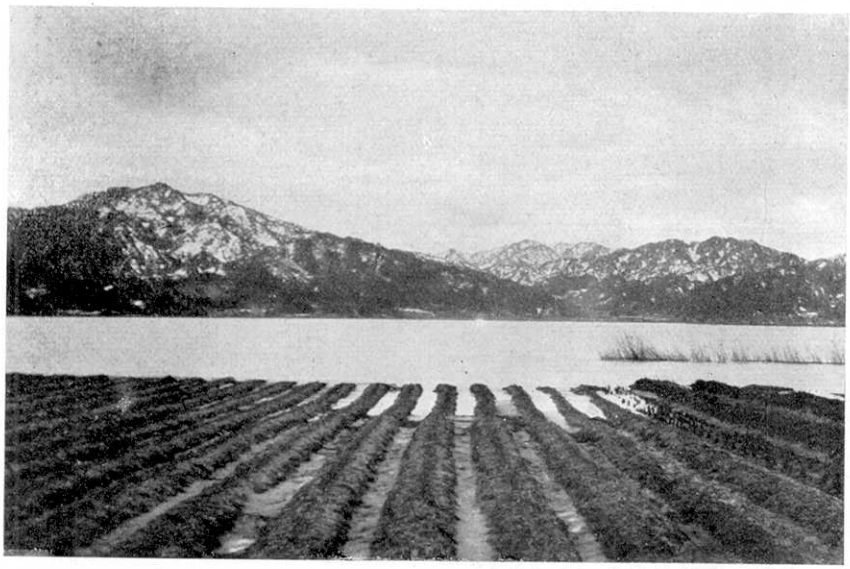
Fig. A. The Yamada fault making a remarkable flexure on cultivated land and Mineyama highway instead of a steep rift.



Yamasaki Photo.

Fig. B. The Yamada fault making a fracture cut deep into granite, near the Shiroyama tunnel.

（震研彙報第四號、圖版、山崎、多田）



Yamasaki Photo.

Fig. A. Submergence of a part of paddy fields along the Yamada fault in Otokoyama on the shore of the Bay of Yosa.

Yamasaki Photo.

Fig. B. Large rifts of the Yamada fault in a mulberry field of the village of Yamada.

Fig. A. A monument in Mineyama was broken and fell down.

Fig. B. Village houses in Yamada, destroyed by the shock.

（震研彙報第四號、圖版、山崎、多田）

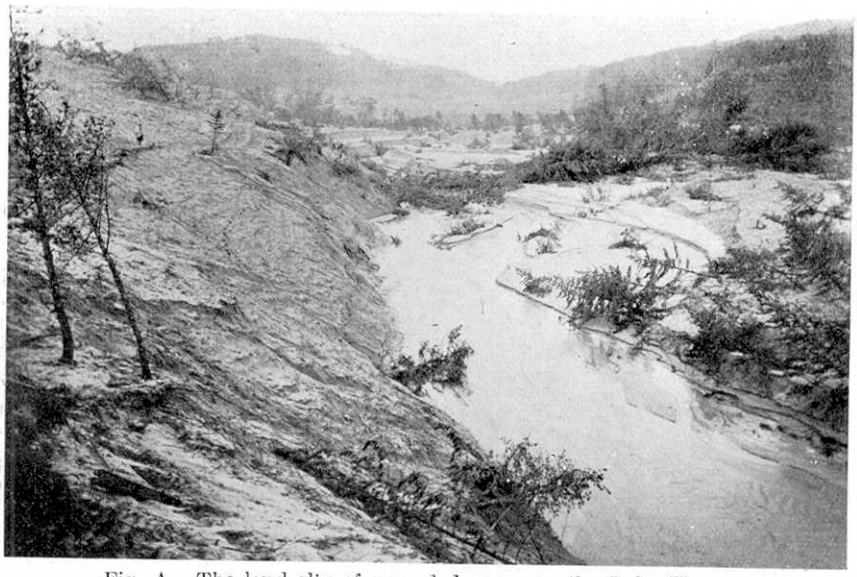
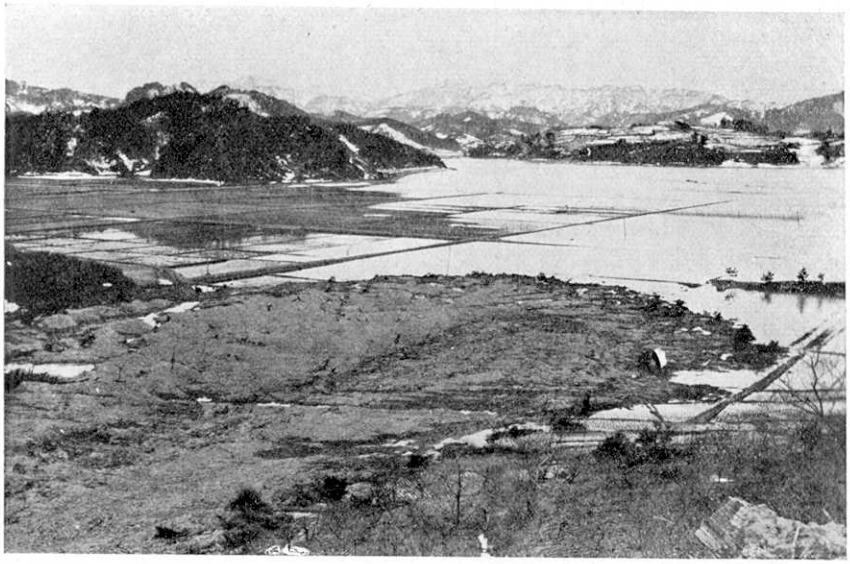


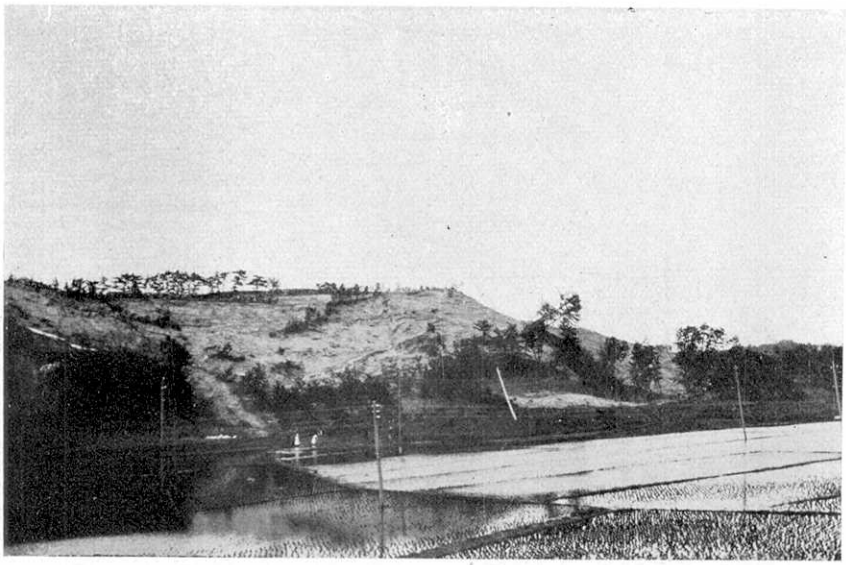
Fig. A. The land slip of a sand dune, near the Lake Hanare.



Tada Photo.

Fig. B. The tongue of sand masses slipped down into the shallow basin of the Lake Hanare.

（震研彙報第四號、圖版、山崎、多田）



Yamasaki Photo.

Fig. A. The land slip of a sand dune near the Lake Hanare.

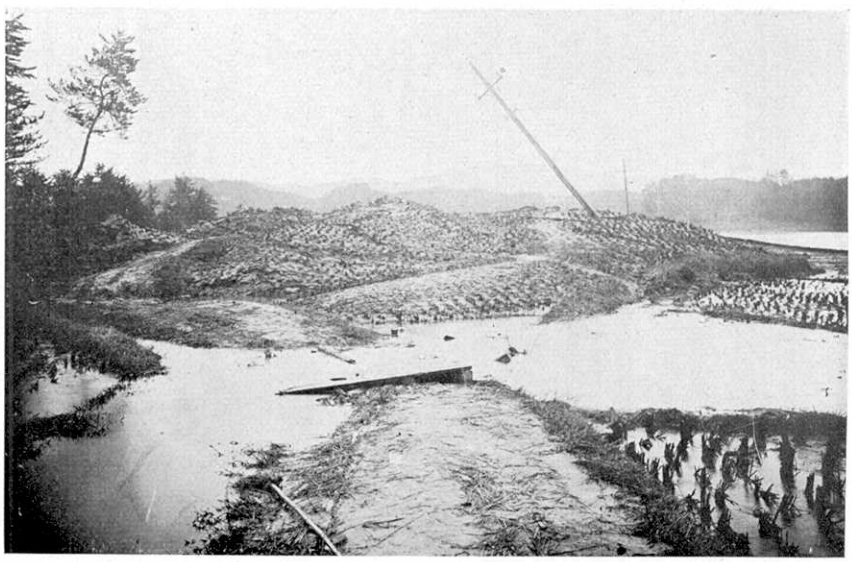


Fig. B. The level surface of the paddy fields on the shore of the Lake Hanare considerably upheaved by the pushing of the tumbled sand masses.

（震研彙報第四號、圖版、山崎、多田）