原著論文

Geotectonics of the Pacific with Reference to South-Western Japan**III. Geotectonics of Central Honshu, the Transverse Rift (Itoigawa-Nirazaki-Sagaminada-Shichito Deep Line) and the Principal Deep Earthquake Zone**

by

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Contents

Introduction	Mountain Land with reference to the
Extension of the Transverse Rift	Transverse Rift
Echelon Structure along the Transverse Rift	Geotectonics of the Transverse Rift and the Principal Deep Earthquake Zone
Geotectonics of the Shichito Submarine Ridge	Summary and Conclusion
Rotational Movement of the Kwanto	References cited

Introduction

B. WILLIS who believes "underthrusting hypothesis" concerning the direction of the lateral thrust of Eastern Asia, considers thus:— "Asia must have been formed by the pressure proceeding from the Indian and Pacific oceans to the Baikal vertex. It was a submarine extension (oceanic spread), in a continuous progress, but manifested spasmodically; which compressed lighter rocks, and Asia was therefore formed, not by overthrusting, but by underthrusting"; and the theory of WILLIS concerning the origin of the lateral thrust from the Pacific is founded upon the idea of making a dynamic centre of the Pacific.

In Japan we have experienced the Shichito- and the Chishima-deeps in the Nippon trench, subjected to the orogenic forces of the Pacific, which may be comparable with those deeps of South America and Tonga-Kermadec; and not only have we discovered the transverse rift associated with the deep-earthquake zone, extending above 2,000 kilometers from the Ogasawara Is. to the Asiatic continent, but the longitudinal tectonic line of the Chishima done with the same zone, extending above 2,000 kilometers from Kamchatka to the same continent. Such may be the facts that verify the theory of WILLIS.

Of the geotectonic researches of the Pacific concerning the Japanese Is., the most important is the study of the tectonic relations among the Nippon trench, the transverse rift, the intermediate and deep earthquake zones, which is now made by the co-operation of the geologist and the geophysicist.

The Nippon trench, one of the longest trenches around the Pacific delineates a

curve extending from Kamchatka-Chishima-Hokkaido via North-Eastern Honshu to Shichito-Ogasawara. Indeed, throughout the greater part of its length it is semi-circular and above 3,000 kilometers long, while the average breadth reaches 100 km. It occupies the north-west corner of the Pacific, and consists of two components of trend, north-east and north-south. The Kamchatka-Chishima-Hokkaido segment belongs to the former, and the North-Eastern Honshu-Shichito-Ogasawara to the latter. None the less they form the same trench, the tectonic structures of both these segments being different as manifested on the one hand by the transverse rift of the Shichito associated with the deep earthquake zone and on the other by the longitudinal tectonic line of the Chishima done with the same zone.

The transverse rift which may have penetrated into a profound depth gives rise, on the one hand, to the mountain building on the upper surface, and, on the other, to the deep earthquake in depth. In length it may surpass 2,000 kilometers, and extends from the southernmost Ogasawara Is. to the Asiatic continent traversing Honshu and the Japan Sea, while it may reach even to the depth of above 500 kilometers.

The paper deals chiefly with the tectonic study of the transverse rift of the upper surface and the deep, with reference to the Nippon trench subjected to the orogenic forces of the Pacific, while the longitudinal tectonic line of the Chishima will be stated in the next paper for expedience' sake.

Extension of the Transverse Rift

It was T. TOKUDA who first recognized the echelon of the Alpine ranges of Central Honshu, together with, that of the volcanic chains on the north-east portion of the Shichito submarine ridge. At that time he believed that the Japanese echelons were the coulisses forming the north wing of the Mariana echelon which was pushed out from the north-west toward the Pacific. Consequently, but unfortunately, the importance of the Itoigawa-Nirazaki-Sunto line was entirely overlooked by him.

The Itoigawa-Nirazaki-Sunto line which was first defined by H. YABE who prolonged the same line from Nirazaki to the deep of Sagaminada, appears tectonically and mechanically to have the closest connection to the echelons of TOKUDA, in the sense of the compression echelon cracks or foldings of S. FUJIWARA.

In the Sagaminada, the Itoigawa-Nirazaki-Sunto line may be elongated far from north-west to south-east along the deep which is parallel to the north-east margin of the Shichito batholith of N. KUMAGAI, to the end of the same margin; whence, however, the line may be prolonged into the Shichito trench which runs to the north-south and extends to the east of the Ogasawara Is., containing three long troughs whose depth reaches 9 kilometers more, the deepest in the Nippon trench. The Shichito trench may manifest the tectonic line which delimits the Sima crust of the ocean floor from the Shichito batholith.

The tectonic line containing the Itoigawa-Nirazaki-Sunto line and whose elongation into the Shichito trench may be expediently called as the "transverse rift" because it transverses Central Honshu. At the beginning of the Miocene age the Shichito trench had been subjected to the orogenic force of the Eastern Pacific, which was resisted by the Ogasawara ridge and the Shichito batholith, while it subdued the outer zone of Central Honshu, the geologic formations of the Kwanto range. The shearing movement of the range along the transverse rift, to which the echelon structures of the sea floor and land of Central Honshu may be due,

would be 60 kilometers from the crossing of the median line which is represented by the distance between Lake Suwa and the town of Ômachi.

Echelon Structures along the Transverse Rift

The eleven coulisses (1~11) of echelon structures developed along the transverse rift, on the sea floor and the land of southern Central Honshu, in turn are to be described.

1), 2) The echelon cracks running from north-east to south-west, which may be defined by the rows of the volcanoes, on the Shichito submarine ridge, are the Hachijo volcanic chainlet and the Ôshima. The origin of these chainlets may be due to the shearing movement, caused by the north-west shifting of the Kwanto range along the north-east margin of the Shichito batholith, corresponding to the transverse rift, by the orogenic force of the Pacific, which pushed into the outlet of the Sagaminada deep.

According to the chart, published lately by the Hydrographical Department, the occurrence of a plateau whose isobath shows 2 kilometers, and width 180 kilometers, extending to the north-south of the Hachijo Is. may be remarked on the Shichito submarine ridge. The extension of the plateau is almost identical with the main mass of the Shichito batholith which is verified by KUMAGAI, to exist under the ridge by the submarine gravity survey. On the plateau there are two flat and wide tablelands whose isobath show 1 kilometer; one of which is around the Hachijo Is. and the other attached to the Izu Peninsula.

The Hachijo chainlet, extending from south-west to north-east lies on the former, while the Ôshima, whose trend is from south-west to north-east does on the latter. The Hachijo chainlet consists of the Hachijo volcanic Is. and many of the submarine volcanoes and shoals, while the Ôshima, does of the volcano Ôshima, Toshima, Utoneshima, Nijima, Shikineshima, Kôzushima, Zenisu and other shoals. The two volcanic chainlets are built on the Shichito submarine ridge and form an echelon together with those ranges of Hida, Kiso and Akaishi.

The middle and south portions of the Mino-Hida plateau which occupies the widest part of Central Honshu, are intruded by the granitic batholith, while the rest of the west, the east and a part of the north occupied by the Palaeozoic. The general trend of the eastern Palaeozoic is north-east to south-west, but with its approach to the transverse rift it becomes north-south, and forms an echelon which may usually be observed in the ranges of Akaishi, Kiso and Hida. The origin of these ranges may be due to the shearing movement, caused by the north-west shifting of the Kwanto range, along the transverse rift, whose distance may be defined as 60 kilometers from the crossing of the median line.

The echelon raised up by the movement belongs to the compression echelon folds or cracks of FUJIWARA, which may be witnessed in the Akaishi, Kiso and Hida ranges.

3), 4) The echelon cracks running from north-south to south-west which may be defined by the rows of volcanoes, on the east and the west coast of the Izu Peninsula, are the Hakone volcanic chainlet and the Fuji. The origin of these is the same as that of the Hachijo and Ôshima mentioned above; that is may be due to the shearing movement, caused by the north-west shifting of the Kwanto range along the north-east margin of the Shichito batholith, corresponding to the transverse rift, by the orogenic forces of the Pacific, which pushed into the outlet of

the Sagaminada deep.

The Hakone chainlet consists of those volcanoes-Hakone, Yugawara, Taga, Usami, Ômuroyama and Amagisan; while the Fuji does of the volcanoes-Fuji, Ashitaka, Daruma, Tanaba, Nekko and Tyokuro-yama according to H. TSUYA. The two volcanic chainlets are built chiefly on the Izu Peninsula and form an echelon together with those of the volcanic islands, Hachijo and Ôshima as well as with the Alpine ranges of Akaishi, Kiso and Hida.

5) The Fujikawa-Suruga Bay coulisse is occupied by the Fujikawa R. and the submarine valley of Suruga Bay, both of which are running toward the north-south. It consists chiefly of the Nishi-Yatsushiro series of the Miocene age running to the north-south, which is limited on the east by the north-south fault from the Shichito batholith lying beneath the Izu Peninsula, and on the west by the Nirazaki-Shizuoka line from the Akaishi sphenoid. The coulisse corresponds to the Senoumi coulisse of TOKUDA, which is a bank of Suruga Bay. As the writer stated in another paper, the north-south submarine valley of Suruga Bay, which is the elongation of the Fujikawa R. occupies 105 kilometers in length, and at the point where the submarine valley touches the Nankai trench the depth reaches 3,600 meters. In its scale, the grand valley may be compared with the Akaishi and Hida ranges containing peaks whose height reaches above 3,000 meters.

6) The Akaishi range is the so-called Akaishi sphenoid of E. NAUMANN; it belongs to the outer zone consisting from north to south of the Crystalline schist, Palaeozoic, Mesozoic (Mikura series) and the Tertiary; of which the former two running north-south and traversed obliquely by the transverse rift at the top, are participated in the formation of echelon while the others running north-east to south-west and occupying the south portion are cut, on the east by the Nirazaki-Shizuoka line running north-south, and form the base of the sphenoid. It may be the compression echelon foldings whose trends are north-south subjected to the lateral thrust from the east and west. It forms two or more ranges containing peaks of above 3,000 meters and the valleys running down between them. Of the trend of the median line which is manifested by the Toyohashi-Suwa arc, the north-south portion between Urakawa and Suwa corresponds to the trend of the Akaishi coulisse.

The Toyohashi-Suwa arc of the median line may chiefly have been formed by the pushing of the Shichito batholith and the shearing movement along the transverse rift, which have bent the outer zone of the South-western Japan, around the south-east margin of the granitic batholith occupying the south part of the Mino-Hida plateau. But there are certain geologic signs that in the early Miocene times an orogenic movement associated with the depression of the Japan Sea might have happened in the region of the same sea, which pushed out North-East Honshu from west to east, and the Mino-Hida plateau from north-west to south-east. Hence the Toyohashi-Suwa arc might have been formed by the two lateral thrusts (the Pacific and the Japan Sea movements) coming oppositely; one from south-east to north-west, the other from north-west to south-east.

7)~10) On the inner north-west side of the Akaishi range there are the Inasan coulisse consisting of the Ryoike gneiss; the Kiso coulisse of the Palaeozoic and the granite; the Hachigamori coulisse and Jyonen, both of which consist of the Palaeozoic respectively. Outside the Inasan coulisse, however, they are not so remarkable as the Akaishi. Their trends of the Palaeozoic are north-east to south-west and there are tendencies to get near the north-south with their approach to the transverse

rift, which passes through the Matsumoto basin.

11) In the Hida range, however, we meet with the grand coulisse which forms the high Alpine range of Japan. On the north side of the Palaeozoic running west-east through the city of Takayama, there is a thick granitic series, whose outside is occupied by the zone of the Hida gneiss running from south-west to north-east. The granitic series run, first to the west-east, increasing its height with its approach to the transverse rift; and near Kamikôchi the trend changes to the north-south from north-east, where the height of Mt. Yari and Mt. Hodaka reaches above 3,000 meters. By the longitudinal valley of the Kurobe River the north-south range of the granitic series is divided into two at Mt. Washiha, represented by Mt. Hakuba and Mt. Tateyama. After proceeding to the north parallel to the transverse rift, they decrease somewhat their height near the north end, where the granite of the Hakuba range is overlaid by the Palaeozoic, developed at Oyashirazu on the coast of the Japan sea, and change the trend to the west as rolling up toward the Toyama plain. The inner side of the granite of the Tateyama range is made of the above-mentioned, Hida gneiss, coming from the south of the Toyama plain, and forms the Tateyama range which rolls up at the same time with the Hakuba range toward the Toyama plain. The gorge of the Kurobe River is flowing between both the ranges of Hakuba and Tateyama, which contain many crests whose height reaches almost to 3,000 meters forming the Hida range, the north Alpine range of Japan.

The Hida range which consists chiefly of granite and gneiss, might be subjected to the compression both from east and from west. In the Hida range, together with the increase of height, the longitudinal cracks running north-south, through which the andesites erupt, are observed on both the ranges, Hakuba, and Tateyama. The gorge of the Kurobe River also may be attributed to the longitudinal cracks running north-south caused by the compression both from east and from west.

Norikura, Ontake and Yakedake, the famous volcanoes of the Mino-Hida plateau, may have erupted on the tectonic line produced by the formation of the Kiso, Hachigamori and Jyonen echelons, which in turn were produced by the shearing movement of the transverse rift.

On the inner side of the Hida gneiss, there are the Neogene Tertiary around the Toyama plain, dipping the north and bounded by a fault from the gneiss. There may be observed along the lower course of the Shokawa R. some faults running from north-east to south-west associated with the disturbed strata, and an anticlinal folding at the neck of the Noto Peninsula.

The Hida gneiss occupies the neck of the Noto Peninsula, which may be elongated to the west-east on the north side of Toyama Bay. Toyama Bay may be a depression which is caused by the rolling up of the Hida range which encloses the Hida gneiss.

The Noto Peninsula consists of the Tertiary of the Miocene age, which forms an anticlinal whose trend is west-east.

To the north of the Noto Peninsula, and in the middle of the Japan Sea, there is the Yamato submarine bank which rises up sheer from the sea floor of 2,000 meters depth up to 300 meters. It consists of two parallel banks whose trends are south-west to north-east, separated by the deep of 2,000 meters. By the dredging, some pebbles composed of those rocks, Palaeozoic, granite, Quartz porphyry, andesite and others which are usually met with in the Chugoku regions, are drawn up from the thin overlying layer of the foundation rock, from which those pebbles

may have come got.

According to H. NIINO, the Yamato bank might be the land remains which formerly occupied the Japan Sea to some extent.

The Yamato bank whose outline is strikingly similar to the Noto Peninsula is connected to Chugoku by the shallows which is elongated to the north-south and contains the Oki Is. In size, the Yamato bank is larger than the Noto Peninsula; it encloses the latter and there is the deep of 3,000 meters between them, the so-called "Cul de Sac" by B. KOTO, who compared it to Toyama Bay.

On the north of the Noto Peninsula, but to the south of the Yamato bank there is a 1,000 meters isobath projecting to the north, where the Nanatsushima Is. and Hekura Is. lie. The submarine promontory resembles Hida range stretching north-south, which may have relation to the depression of the Cul de Sac.

The transverse rift may traverse the Japan Sea, from Itoigawa to the Asiatic continent passing on its way the east of the Noto Peninsula and the Yamato bank. The foci of the Principal deep earthquake zone in the sea and continent which is parallel to the trend of the transverse rift may be the reliable ground for the tracing of the same rift.

For the deep earthquake zone of the Chishima, the Yamato bank and Cul de Sac supply the important geologic ground. The tectonic line which divides the outer zone of the Chishima from the inner, may be prolonged from Nemuro via Kushiro passing the Tsugaru Straits to the middle of the Japan Sea, where it passes the deep which lies between the banks. The tectonic line is parallel to the deep earthquake zone of the Chishima and may be compared to the transverse rift.

Geotectonics of the Shichito Submarine Ridge

The Shichito trench, a south portion of the Nippon trench, which appears to be a portion of the suboceanic bent-down crust by the orogenic force of the Pacific, may once have extended north-south from Cape Inubo to the east of the Ogasawara Is. By being subjected to the orogenic pressure originated in the profound depth of the eastern Pacific, however, it has faced the convex side toward the west and come to press the Shichito submarine ridge. Consequently, the north-south abyssal basin of 4,000 meters in depth between the Ogasawara Is. and the Shichito submarine ridge was cut by the trench, to the north-west of the Ogasawara Is., while to the south of the Cape of Inubo, the trend of the trench has turned strikingly to the west, and come to approach the Shichito submarine ridge. Prior to the movement, the Ogasawara ridge, the Tertiary mountain range in the Pacific, may have extended to the north farther than now; but how far it is, is not clear.

The Shichito submarine ridge makes a boundary with the Shichito trench, whose distance is above 500 kilometers from north to south extending between the east of Ôshima and Sofu rock; beyond which both of them diverge from each other. In the above-mentioned distance, however, one may recognize the following remarkable influences which the trench gives to the submarine ridge and the outer zone of South-Western Japan, on the tectonic structures, of the sea floor and land.

- 1) The tapering apex of the Shichito batholith, first might have been applied obliquely to the outer zone of South-Western Japan, running to west-east, and under the lateral thrust of the Shichito trench it has pushed into the Kobotoke series, by traversing the Nankai trench, by which the submarine continental slope of the former is bordered.

The interval of the pushing of the batholith into the Kobotoke series may be 130 kilometers, which is represented by the length of the north-south fault between the batholith and the Misaka series (Nishi-Yatsushiro group), whose existence may be suspected along the submarine valley of Suruga Bay, stretching from the mouth of the Fuji River to the eastern end of the Nankai trench.

The arcuate bending of the outer zone, manifested by the Toyohashi-Suwa arc, a portion of the median line, is attributed to the pushing in of the Shichito batholith, accompanied by the co-operation of the shearing along the transverse rift.

The time of the tectonic movement is assigned to the beginning of the Miocene by the study of volcanism and the Neogene deposits of the Fossa Magna. The orogenesis seems, however, to have twice occurred in history, the first, in the beginning of the Miocene; and the second in the early Pleistocene. The idea was first remarked by R. ÔHASHI of Akita University, which was afterwards taken up by the writer. The early Pleistocene movement is considered to be the repetition of the movement of the Miocene, that is, the pushing of the Shichito batholith into the Misaka series containing *Lepidocyclina*, which formed an arc of the Misaka-Miura-Bôso. But at that time, whether there was the co-operation of the shearing movement along the transverse rift, is not clear.

2) The northwestern portion of the Shichito batholith which is represented by the +50 milligal isanomaly, whose margin runs to north-east to south-west along the Nankai trench of the Yenshunada has pressed the latter from south to north, by the compression of the Shichito trench; and by reducing the width of the trench, made it more accessible to the land.

3) The compression of the Shichito batholith by the Shichito trench has spread the lateral thrust through the bottom of the South Japan Sea toward South Kii, where the Nankai trench running west-east is pushed from south to north, by making the trench more accessible to the land. In South Shikoku, the Nankai trench running north-east to south-west is pushed from south-east to north-west, causing the depression of Tosa Bay; which in the Ashizuri Peninsula the lateral thrust from the Pacific, is remarkably limited, extending only in the area on the south of the west-east line connecting the town of Sukumo and that of Nakamura.

The lateral thrust, however, appears to have pushed the submarine layers from east to west, which construct the continental slope under the Bungo Straits and Ryukiu Is.

4) The Fuji volcanic zone which was first brought to light by H. TSUYA, consists of the volcanoes on the Shichito submarine ridge, which stand in a line running from north-north-west to south-south-east, parallel to the Shichito trench. It may be a fracture line whose origin may be due to the shearing movement that took place within the Shichito batholith in the direction north-north-west to south-south-east by the lateral thrust of the Shichito trench. On the fracture line, the eruption of the volcanoes may be remarked; particularly in the area where the Shichito trench and the Shichito submarine ridge make contact in the interval of 500 kilometers. They are from south to north as follows; Sôfu rock, Torishima, Smith Is., Beyoneseshima, Aogashima, Hachijo Is., Mikurashima Is., Miyakeshima, Toshima, Amagi, Ashitaka and Fuji. Lately, T. SAMESHIMA of Shizuoka University who has remarked the recent submarine eruption of the Myojin reef lying to the east of Beyoneseshima has proposed his opinion on the regular shifting of the periodic eruption of the volcanoes on the Shichito submarine ridge, from south to north. This may be an interesting problem with reference to the Shichito trench.

To the south of Sôfu rock on the Shichito submarine ridge, the directrix may be elongated to the south-south-east toward the Volcanic Is. passing on its way Nishinoshima, west of the Ogasawara Is.; farther, by following its direction it may stretch to the south-south-east and reach the east of the Yap Is.

5) From the seismic study around the Japanese Is. H. HONDA has classified the depths of the earthquakes into three kinds; shallow (~ 100 kilometers), intermediate ($100\sim 250$ kilometers) and deep ($250\sim 550$ kilometers), of which he has remarked that the intermediate earthquake is associated with the volcanic zone as well as with the higher zone of Geoid.

On the inner side of Tohoku Honshu and to the north of the Fossa Magna, there are volcanoes which may be connected by a straight line which is assigned as the tectonic line of the region (the Nasu volcanic chain, Kayagatake-Yatsugatake-Tateshina line and others). They are associated with the intermediate earthquake, but with the exception of the deep earthquake. In the Fuji volcanic chain, however, there occur both the earthquakes; deep and intermediate.

The hypocenters of intermediate earthquake occurring beneath the Shichito submarine ridge and the Fossa Magna, form a zone extending from south-south-east to north-north-west parallel to the fracture line of the Fuji volcanic zone. The fracture line which manifests the fault plane may have penetrated deeply far within the earth into 250 kilometers in depth, which is the downward limit of the intermediate earthquake, where it may diverge from the fault plane of the transverse rift which is dipping westward, and passing to the west.

The depth of the volcanoes is usually considered to be more shallow than that of the intermediate earthquake, and what tectonic relation exists between them is not yet clear at present. The transverse rift may be a fault plane which dips to the west from some distance below the Shichito trench; it passes the bottom of the intermediate earthquake, whereabouts, however, it may bend acutely to the west, and extend to the depth of above 500 kilometers. For the fault plane of the transverse rift, dipping to the west there may be an underthrust from the Pacific, and an overthrust from the continent.

Rotational Movement of the Kwanto Mountain Land with reference to the Transverse Rift

On the outside of the Crystalline schist series which occupies the north portion of the Kwanto range extending west-west-north to east-east-south, the existence of the median line may be supposed, parallel to the Tone River. To the east-east-south the median line may stretch from the city of Takasaki via Iwatsuki toward the Pacific (Kujukurihama beach), while to the west-west-north along the Karasugawa R., it passes the north of Azumaya volcano toward the city of Nagano. To the west, from Nagano running parallel to the course of the Saikawa R. it passes along the Susohana R. toward the town of Ômachi, where it intersects the transverse rift obliquely.

The median line which is manifested by the above-mentioned Nagano-Takasaki-Iwatsuki line, contacts the mountain blocks of Tsukuba, Ashio and Mikuni, belonging to Tohoku Honshu. It may be the tectonic line which has moved to the north-west and dragged the Ashio range to the north-west, which is manifested by the Nasu volcanic chain of Tohoku Honshu, running along the range from north-east to east-west. But the occurrence of the fractured zone along the tectonic line, and

the existence of the echelon structure in the mountain blocks are not evident as yet.

The peculiar occurrence of the Iwatsuki earthquake on the tectonic line is remarked by B. Koro, which may have relation to the movement of the line.

The west and east sides of the Kwanto range are cut by the north-south faults, the Chikuma River and the Sagami River. The Chikuma River fault and the transverse rift form a depressed basin in the Fossa Magna, in which the Tateshina-Yatsugatake and Kayagatake volcanoes erupt, probably on the fault line parallel to the transverse rift. The depressed east portion of the Kwanto range which is cut by the Sagami River fault, forms the Tokyo basin, filled up by the Neogene Tertiary and the Pleistocene. The geologic structure of the basin may be an onion-like arrangement around the center of the Pleistocene series developed at the head of Tokyo Bay, which is underlain by the Neogene Tertiary, dipping toward the center, and subjected to the underthrust from the Pacific, as in the case of the Kwanto earthquake.

The formations of the Kwanto range are arranged from north to south in the following order- the crystalline schist, the Mikabu, the Chichibu and the Kobotoke series, but the boundary between the Chichibu and the Kobotoke is not yet clear. The depressed south portion of the Kobotoke series is occupied by the Misaka series intruded by the granodiorite, which forms the Dôshi range. The region which is occupied by the Nishi-Yatsushiro series of the valley of Fujikawa, the Misaka and Dôshi ranges, the Fuji and Ashitaka volcanoes might have been the depressed basin in the Fossa Magna, caused by the pushing in of the apex of the Shichito batholith and partly by the shearing movement of the transverse rift.

The protruded apex of the Shichito batholith may first have been obliquely applied in the direction of the north-north-west to the south margin of the Nankai trench running west-east, and by the enormous pressure of the Nippon trench, it has pushed itself into the Kobotoke series to the extent of 130 kilometers, which is manifested by the length of Suruga Bay. The bending of the outer zone of South-western Japan, done by the Toyohashi-Suwa arc, a portion of the median line, may be attributed to the pushing of the batholith, associated with the shearing movement of the Kwanto Range along the transverse rift, and at that time, the movements have given the Kwanto range a rotation, and brought it to the present position.

Geotectonics of the Transverse Rift and the Principal Deep Earthquake Zone

Japanese Seismology has made a contribution by first discovering the deep earthquake by J. SHIDA, which afterwards has been studied and confirmed by K. WADACHI and H. HONDA, according to whom from the Nippon trench to the Asiatic continent an existence of a plane dipping 45° to north-west may be supposed to exist within the earth, in which the hypocenters of shallow, intermediate and deep earthquakes may be contained respectively; and there may be an underthrust for the plane from the east, but an overthrust from the west.

H. H. HESS of the Geological Institute of Princeton University, who studied the distribution of the seismic zones around the Japanese Is. has noticed, that the shallow and intermediate earthquakes are associated with the volcanoes and the island arcs; they run from the Chishima, via Hokkaido into Tohoku Honshu and the Shichito; but the distribution of the deep earthquake zone is strikingly different from them. In the Okhotsuk Sea there is a deep earthquake zone which runs

parallel to the arc of the Chishima, from north-east to south-west and reaches the Asiatic continent running in the same direction and passing on its way the Soya straits and the Japan Sea; while there is the other, which lies to the west of the Shichito, running from south-east to north-west traversing the Honshu Is. and the Japan Sea, and reaches the Asiatic continent. In reanalysing GUTENBERG's data and RICHTER's, HESS has supposed an existence of a discontinuity, a transition zone, among the hypocenters of the deep earthquake, whose depth may be defined as 475 kilometers.

The transverse rift may reach from the Shichito deep to the Asiatic continent passing the Fossa Magna and the Japan Sea, parallel to the Principal deep earthquake zone which may be considered to have a close connection between them. Similarly, in the Chishima the longitudinal tectonic line which lies between the outer and inner zones is parallel to the deep earthquake zone and there may be a close connection between them.

H. BENIOFF who studied the elastic strain-rebound characteristics and related spatial distribution of foci of the seismic sequences of South America and the Tonga-Kermadec regions has noticed that the orogenic feature associated with these two structures represent the surface expressions of great faults extending 650 kilometers in depth and up to 4,500 kilometers in length. His study is valid and agrees with us in the geotectonics observed on the upper surface from the geological side.

On the GUTENBERG's data and RICHTER's, he has studied the Chishima-Kamchatka segment and noticed not only that the intermediate component extends to a depth of 300 kilometers and dips under the continent at an angle of 34° ; but also that the deep component, with a dip of 58° to north-west, appears to have undergone a horizontal displacement of approximately 100 kilometers westward (toward the continent) relative to the intermediate component, by intersecting on the 300 kilometers level. His study may have indicated that the deep component has undergone a horizontal displacement, on the 300 kilometers level by the underthrust from the Pacific.

Moreover, Benioff has described the Bonin-Honshu segment on the basis of the Gutenberg's data and Richter's. According to him, intermediate component extends from the surface to a depth of 400 kilometers; the fault dips westward under the continent at 38° . The deep component, however, is displaced horizontally eastward, away from the continent, some 200 kilometers relative to the intermediate component, with 75° dip to the westward, the largest of any studied up to now.

In this respect, the writer is obliged to propose a different consideration about his profile of the Bonin-Honshu segment. According to the map of GUTENBERG and RICHTER, as well as that of Honda, the deep earthquake zone of the Fossa Magna occupies distinctly the west side of the intermediate earthquake, and there can not be the eastward displacement of the deep component, relative to the intermediate. If there may be any displacement between the two components, the deep component must have been displaced horizontally westward (toward the continent) by the influence of the Pacific.

BENIOFF seems to have laboured under the interpretation of the tectonic relation between the deep earthquake zone of the Chishima-Kamchatka and that of the Bonin-Honshu, both of which intersect in the continent as. HESS and others have remarked. The Chishima-Kamchatka and the Bonin-Honshu segments are not the same geologically, and can not be connected as he supposes. The transverse rift of

Honshu, and the longitudinal tectonic line of the Chishima have been formed under the different tectonic conditions, by the lateral thrust from the Pacific.

Summary and Conclusion

1) The transverse rift may have happened in the Shichito trench by the orogenic force of the Eastern Pacific, whose north extension reaches the Asiatic continent, while the south does the east of the Ogasawara Is. The shearing distance on the rift may be defined as 60 kilometers from the crossing of the median line in the Fossa Magna.

The Fossa Magna is defined by E. NAUMANN as the region having a certain width, and extending north-south; it may be a fracturing and depressed zone associated with the transverse rift, penetrated by many secondary faults parallel to the principal fault (the transverse rift), through which volcanoes erupt out.

The echelon structure that happened along the transverse rift, may form a vortex in the climax of development, which may usually be observed in the boundary of air currents flowing in two directions opposite to each other. The depression of Toyama Bay may be attributed to the rolling up of the vortex motion of the Hida granitic range.

2) First, the Kwanto range may have extended to the west-east toward the Bôso Peninsula; but by the pushing of the Shichito batholith into the Fossa Magna, and the shearing movement of the range along the transverse rift, the western end of the range may have been brought about toward the north, up to the present position. So, the north-north-west to south-south-east trend of the range may be due to the rotational movement.

3) The transverse rift may be a fault plane which dips to the west from some distance below the Shichito trench; in advancing some distances to the west, however, it diverges a fault plane upwards, whether erect or not, which corresponds to that of the intermediate earthquake. Then the fault plane of the transverse rift may bend acutely toward the west and form that of the deep earthquake.

4) The shallow earthquake, off the east coast of Tohoku Honshu, which occurs innumerable under the continental slope may be due to the depression which is attributed to the negative gravimetric anomaly, shifted from the former Sanriku trench seaward under the same slope. It may have a shallow origin and be excluded from the tectonic earthquakes, the deep and intermediate.

5) The granodiorite batholith of the mountain lands of Kitakami and Abukuma, which occupies a part of the outer zone of Tohoku Honshu forms a massif extending north-south, while the inner zone of the same consists of the Neogene Tertiary and the volcanic rocks containing an intermediate earthquake in depth. The transverse rift which might have been formed in the Shichito trench by the orogenic forces of the Pacific, has diverted itself, from the batholith and taken the present course, not identical with the Sanriku deep in the Nippon trench, while the Sanriku deep and the two zones of Tohoku Honshu are pushed out toward the Pacific by the Japan Sea movement.

The intermediate earthquake may be the manifestation of the orogenic force of the Japan Sea movement, the downward limit of which may extend the depth of 250 kilometers. It thrusts the inner zone over the outer of Tohoku Honshu. The deep earthquake may be the manifestation of that force of the Pacific movement, the downward limit of which may reach the depth of 500 kilometers. For the

fault plane of the transverse rift, dipping to the west there may be an underthrust from the Pacific, and an overthrust from the continent.

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西南日本の太平洋地体構造論
——本州中部の横断々層と深発地震帯の地質構造——

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(摘 要)

Transverse Rift は小笠原、伊豆以東の日本海溝を北上し、途中 10,680 m の Ramapo Deep を過ぎ相模灘の口に達する。海溝はこの儘北上して三陸沖に達するのであるが、Rift は北北西に向きを変え相模灘より Fossa Magna 地帯を糸魚川に抜け日本海を北進して東亜大陸に達す。Rift に直接して東側には関東山系の北西大移動あり。西側には日本アルプスの雁行構造ありて動力の本源は太平洋にあるを示している。

深発地震帯は小笠原島の西に始まり Transverse Rift に平行して北北西に走り Rift の変向に呼応して遠州灘附近で向きを変え伊勢湾より再び Rift に平行して若狭湾に抜け日本海を北上してウラジオ附近に達するのである。Transverse Rift と深発地震帯は構造上密接の関係にあるを知るべく其の関係は下の如く考えらる。

Transverse Rift の断層面は日本海溝の下で西に傾き富士火山帯の下では 250 キロの深さに達し、此処から稍深発の地震断層面を地表に向て派出し(これは直立又はそれより少し傾く)、其附近で西に急傾斜して 400 キロの深さに降下し深発地震断層面となる。Transverse Rift 断層面は全体としては西に傾き、太平洋側よりは underthrust を、大陸側よりは overthrust を受けつつありて深発及び稍深発の両地震はそれに基くことが察せられる。