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SUPPOSITION OF DISTRIBUTION OF EARTHQUAKE DISASTER BY SETTING SEISMIC FAULT

By

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Abstract

Relation between distribution of earthquake disaster $Y(\%)$, seismic magnitude M and depth of the seismic fault surface $D(km)$ and distance from the fault are formulated as follows,

$$x_4 = -66.17 - 12.37\,M - (0.345 - 0.0155D)Y,$$

where x_4 is the distance from the fault for 4th grade ground and Y is the ratio of the total collapse to the total house.

And relation of the distance x_n for nth grade ground versus x_4 is formulated as

$$x_n = \frac{(n-0.5)^2}{12.25}\,x_4,$$

For example, a seismic fault is supposed, and distribution of the earthquake disaster are estimated at the Kameoka basin.

Two models of the mechanism of the distribution of earthquake intensity, these are releasing of the field force around the fault, and radiation of earthquake force from the fault. The latter model is more suitable for the distribution.

1. Introduction

It is necessary to estimate the earthquake disaster in near future at an appointed region in order to plan the disaster prevention. Our basic study of the prevention is a setting of a seismic origin and an supposition of a distribution of the seismic intensity.

There are many studies [Kawasumi (1951), Muramatsu (1969), Katsumata et al. (1971) and Kanai (1969)] of the relations between the seismic intensity, the seismic magnitude and the epicentral distance. Especially, K. Kanai has studied also the relations between the ground acceleration et al. and the predominant periods of the ground.

The most important part of the seismic intensity for the disaster is that of the scale higher than IV in the scale of the central meteorological observatory of Japan, for example. That is important to suppose the precise intensity in and near seismic origin.

The author studies a relation between seismic intensities and distances from faults instead of epicentral distances in this paper. He formulates a relation between the earthquake disaster and the seismic magnitude, the depth of the fault surface, distance from the fault and the grade of the ground. And he also tries to set a fault, and supposes the distribution of the earthquake disaster by use of his formula.

2. Earthquake disaster and distance from the fault

It faulted in the direction of N 20° W at the eastern part of the Fukui plain in the Fukui earthquake of 1948. The length of the fault is 26 *km*, and the depth of the fault surface is about 20 *km*. The distribution of the ratio of the total collapse to all houses was published by the Special Comittee for the study of the Earthquake Disaster in Hokuriku (1951). The relation between the ratio of the total collapse on the alluvium in the Fukui plain and the maximum and minimum distances from the fault are obtained and are shown as Fig. 1 (*a*). The signs ●, ○ and × show the maximum and the minimum distances on the alluvium, and the maximum distance on the high land versus the every ratio of the total collapse, respectively.

According to the ground experiments, the grade of the ground by means of the Kanai's method (1969) seems to be the third grade in the Fukui alluvium. And so, it is able to estimate that the sign ● shows the upper limit of the distance for the third grade ground, and sign ○ shows that of the lower limit of the third grade's or that of the upper for the second grade's. Sign × shows the upper limit for the first grade's in Fig. 1.

Fig. 1 (*b*) shows the distance from the fault vensus the ratio of the total collapse at each town and village in the Kita-Tango Earthquake of 1927.

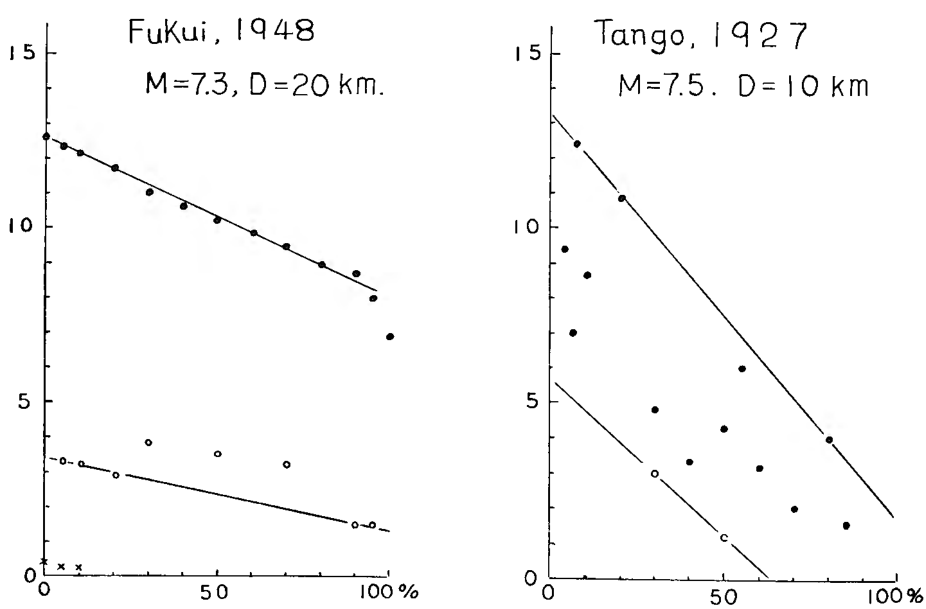

Fig. 1 (*a*) and (*b*). Distributions of ratios total collapsed houses versus distances from faults in the Fukui and the Kita-Tango earthquakes.

According to the ground experiment, the grade of the ground in main residential quarter in this district is the higher and the lower parts in the third grade's. And so, it seems that the distribution of the value in Fig. 1 (*b*) shows the upper and lower limits of that for the third grade ground.

Fig. 1 (*a*) and Fig. 1 (*b*) show the relation between the distance from the fault, x *km*, and the ratio of the total collapse, $Y\%$, is linear as following,

$$x = a - bY, \tag{1}$$

where a and b are constants of each earthquakes.

The relation of the formula (1) is confirmed also in the other earthquake in Japanese Islands. Table 1 shows the seismic magnitude M, the depth of the fault surface, D *km*, a and b of the earthquake and the highest grade of the ground of the earthquake disaster district.

Table 1. The seismic magnitude M, the depth of the fault surface D *km*, constants a and b in (1) and the highest grade of the ground n.

Earthquake		M	D (*km*)	a (*km*)	b	n
Hamada	1872	7.1		19.2	0.360	4
Shonai	1894	7.3		23.6	0.220	4
Riku-u	1896	7.5		31.0	0.530	4
Ugo-sen	1914	6.4		12.5	0.150	4
Tajima	1925	7.0	20	19.2	0.292	4
Kita-Tango	1927	7.5	10	13.4	0.130	3
Kita-Izu	1930	7.0	~5	18.7	0.200	4
Oga	1939	6.6	~5	26	0.350	>4
Mikawa	1945	6.9	10	17.4	0.215	4
Fukui	1948	7.3	20	12.3	0.045	3

Relations of a in (1) versus M, and of b in (1) versus D are shown in Figs. 2 and 3, respectively. According to these figures, these two relations are able to be linear equations. In Fig. 2, the straight line shows the relation for 4th grade's ground. The values of the Oga, the Kita-tango and the Fukui Earthquakes are deviated from the straight line, because the highest grade of the ground around Oga is higher than the ordinary 4 th grade, and because those of Kita-Tango and Fukui are third grade. According to Table I, Figs. 2 and 3, and formula (1), it formulates as follows,

$$x_4 = -66.17 + 12.37\,M - (0.345 - 0.0155D)\,Y, \tag{2}$$

where x_4 is the value of x for 4th grade's ground. The relation between x_4 and x_n of the nth grade's ground is calculated by use of the data of the Fukui and the Kita-tango Earthquakes as follows,

$$x_n = \frac{(n-0.5)^2}{12.25}\,x_4\,, \qquad n = 1,2,3,4. \tag{3}$$

The graphs of the relation of x *km* versus $Y\%$, for examples of $M=6.5$ as $D=2$

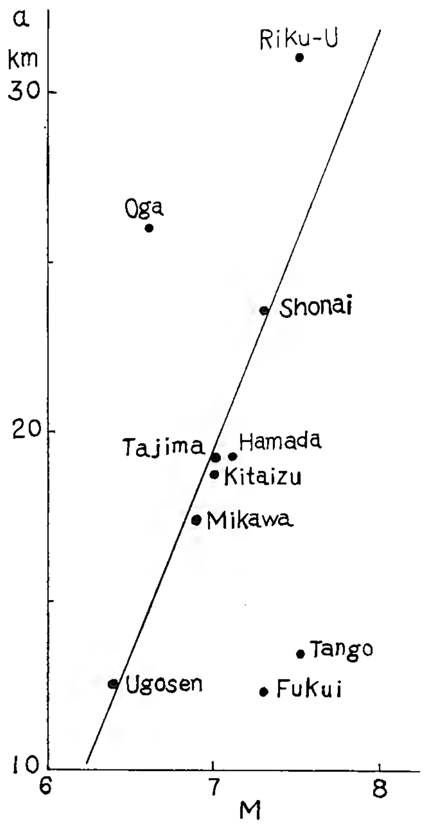

Fig. 2. Relation between *a* in formula (1) and seismic magnitude *M*.

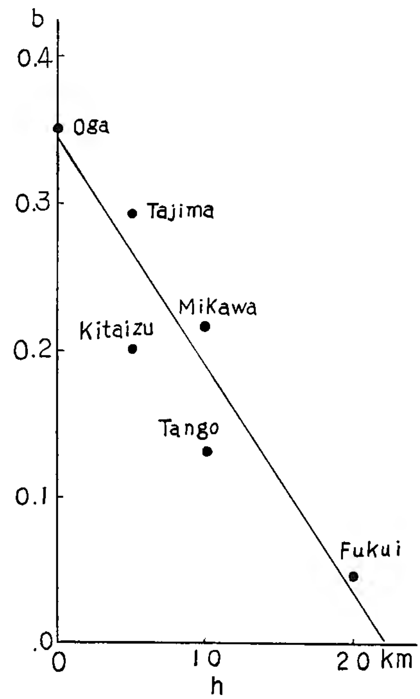

Fig. 3. Relation between *b* in formula (1) and depth of fault surface *D*.

km and 5 *km*, and of $M=7.0$ as $D=5$ *km* and 10 *km* are shown in Figs. 4 (*a*) and 4 (*b*). According to these relations, we can find that the effect of the grade of the ground on the earthquake disaster is little on the fault, the disaster at even the first grade's ground is as large as at the higher grade's.

3. Supposition of earthquake disaster

A supposition of an earthquake disaster is examined for the Kameoka basin of the Kyoto prefecture by the setting of the fault, and by use of the disribution of the grade of the ground and the relation in formulae (2) and (3) as followings.

The earthquake whose *M* is 6.4 occured at the south-east part of this district in 1830. The maximum magnitude is supposed as about 7 founded on the area of the Kameoka basin. Now, it supposes a faulting of 10 *km* long, and the depth of the fault surface is 5 *km*. The magnitude of the earthquake is 7.1. This fault is from Zuiunji of the south-west part of Yagi-cho to Umabori of the east-south part of

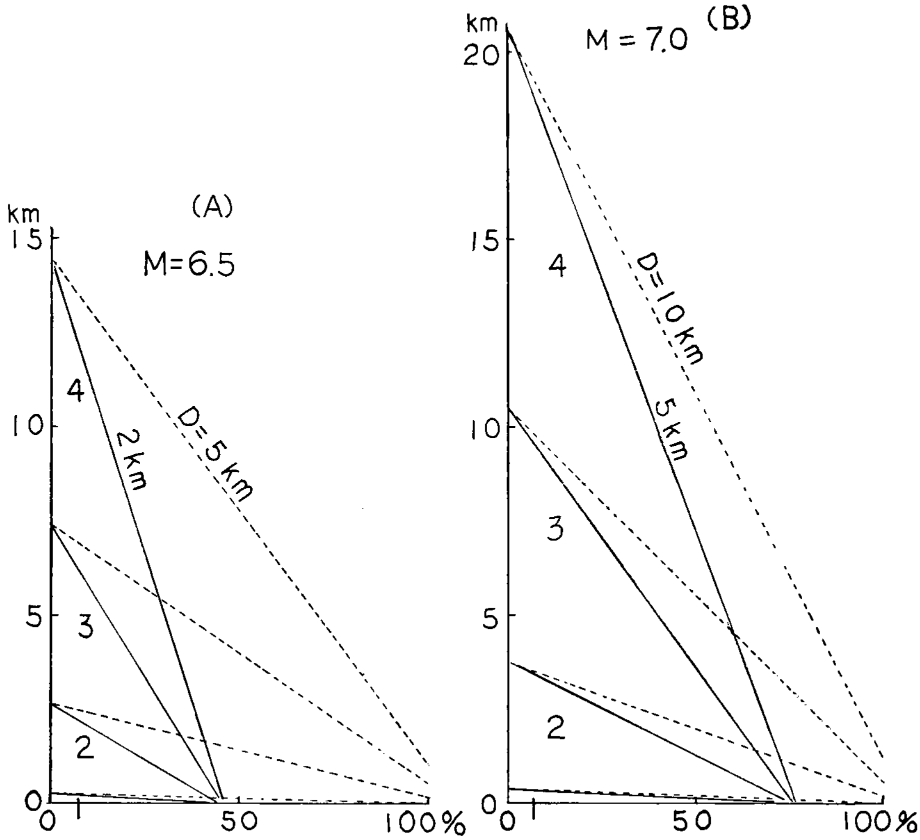

Fig. 4. (*a*) and (*b*). Graphs of ratios $Y(\%)$ of total collaps vs. distances $x(km)$ from faults in $M = 6.5$, $D = 2$ *km* and 5 *km*, and in $M = 7.0$, $D = 5$ *km* and 10 *km*, respectively. Integers 1, 2, 3 and 4 show the grades of ground.

Kameoka-city. The position of this fault is the most probable from the geological and the topographical considerations. The process of the disaster estimation is followings. The fault is drawn on the map. The map is divided into rectangles whose size is 30″ (0.93 *km*) from north to south, and is 45″ (1.13 *km*) from east to west. The distribution of the seismic intensity is determined by use of the distribution of the grade of the ground which was investigated by the entrust of the Kyoto Prefecture, and by use of the relation shown in formulae (2) and (3). The distribution of the seismic intensity is shown in Fig. 5. The mean intensities on the every rectangles are calculated, and are shown in Fig. 6. The unit of integer in each rectanles is permillage (‰), and is equal to the ratio of the total collapse house to the all houses. This value is nearly equal to the force of the earthquake divided by the gravity acceleration by chance. The populations in every rectangles multiplied by the each permillages are equal to the afflicted populations in every rectangles, and these distributions of the afflicted populations are shown in Fig. 7. we can

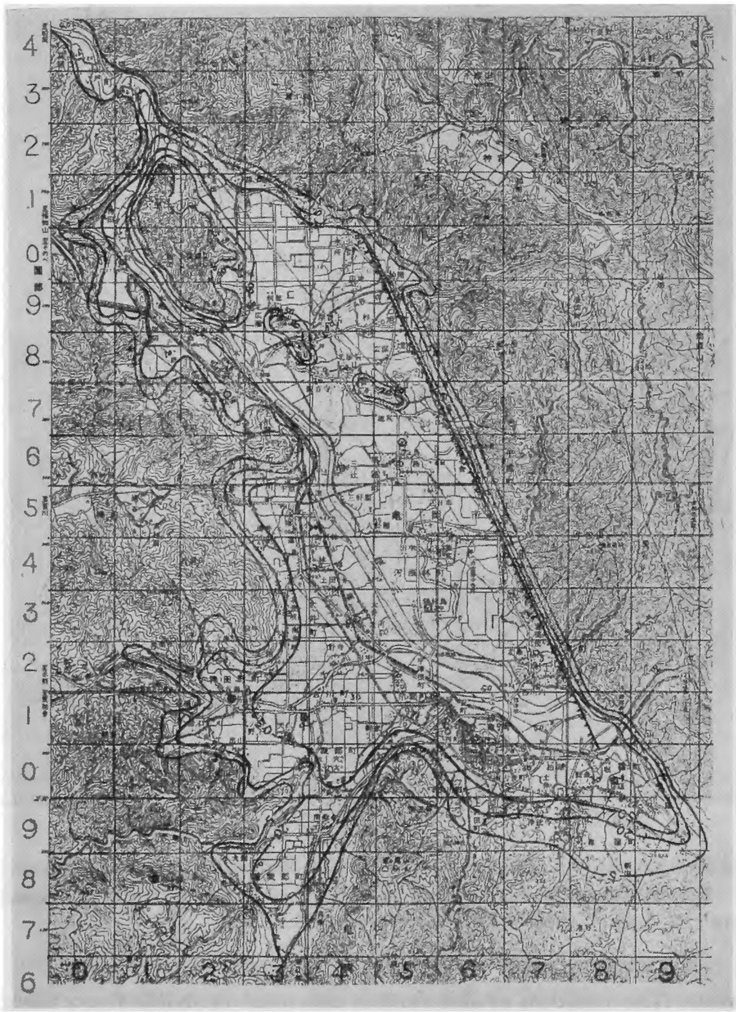

Fig. 5. The location of the fault supposed and iso-seismal lines caused the hypothetical earthquake in the Kameoka basin.

find that the many afflicted populations are not only in the Kameoka basin but also in the south part of the Kyoto basin.

4. Mechanism of distribution of earthquake disaster

Two elementary models are examined to explain the mechanism of the distribution of the earthquake disaster as followings. The first model is that the attenuation of the releasing stress in the field around the fault is linear proportional to the distance from the fault. And the earthquake intensity of the ground is inversely proportional to the rigidity of the ground, because periods of the main

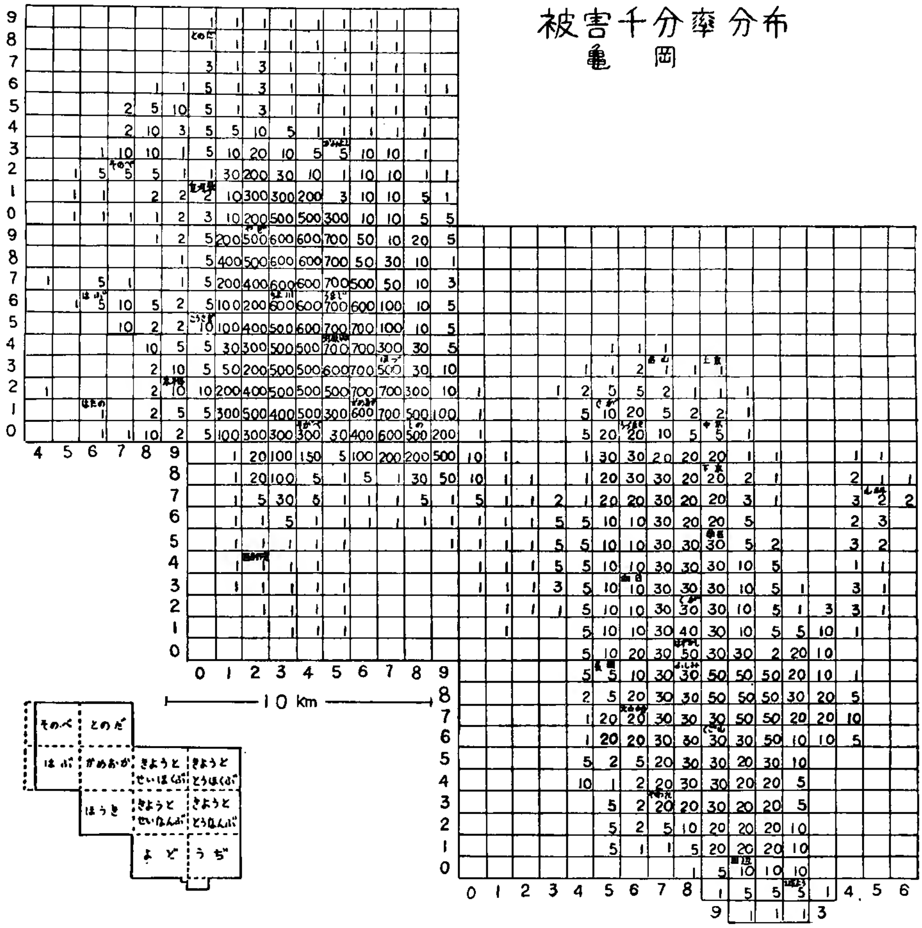

Fig. 6. The distribution of permillages of the disaster in Kameoka and Kyoto districts caused by the hypothetical earthquake.

Table 2. Distribution of earthquake intensity on the first model

Distance from fault	0	1	2	3	4	5	6	7	8	9	10	11
Releasing stress	11	10	9	8	7	6	5	4	3	2	1	0
Rigidity of ground	5	2	1	2	5	5	2	2	1	1	2	1
Earthquake intensity	2.2	5	9	4	1.4	1.2	2.5	2	3	2	0.5	0

earthquake motions are equal around the fault. An example of the attenuation of the earthquake intensity for the distance from the fault in a model region is shown as Table 2 and Fig. 8. The releasing stress is 11 units on the fault. The rigidity

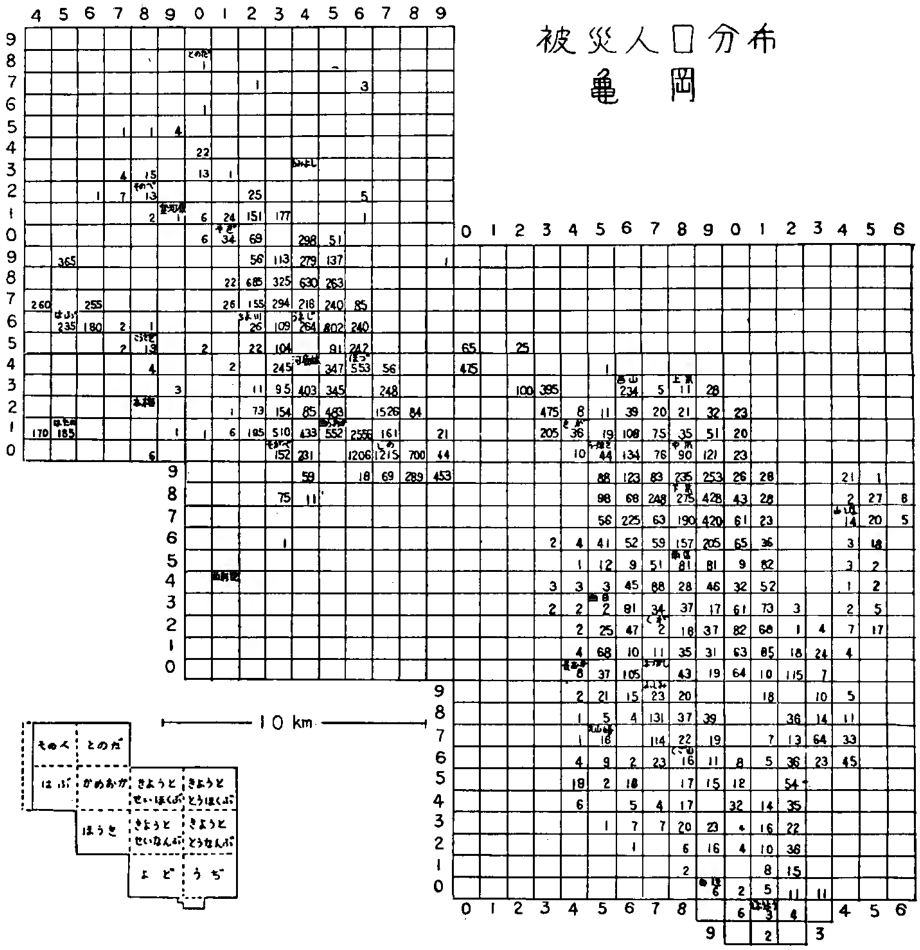

Fig. 7. The distribution of afflicted populations caused by the hypothetical earthquake in the Kameoka and the Kyoto districts.

of the ground is 1 unit on alluvium, 2 units on diluvium, and 5 units on tertiary. The distribution of the rigidity in the model region is shown in Table 2.

In the first model, the attenuation curves for alluvium, diluvium and tertiary are together on the axis which is the intensity is equal to 0 as shown in Fig. 9.

The second model is that the energy of the seismic oscillation is radiated from the fault. This model picture is shown in Fig. 9. For instance, the specific attenuation α of the earthquake intensity is 1 at alluvium, 2 at diluvium, and 3 at tertiary. The attenuation is $\alpha\Delta$, where Δ is the distance from the fault. Let the radiation of the earthquake intensity at the fault be 15, the distribution of the intensity is obtained in the same district as the first model, and is shown in Table 3 and Fig. 9. According to Fig. 9, these attenuation curves for alluvium, diluvium and tertiary are focused at the fault, and are dispersed at distant from the fault.

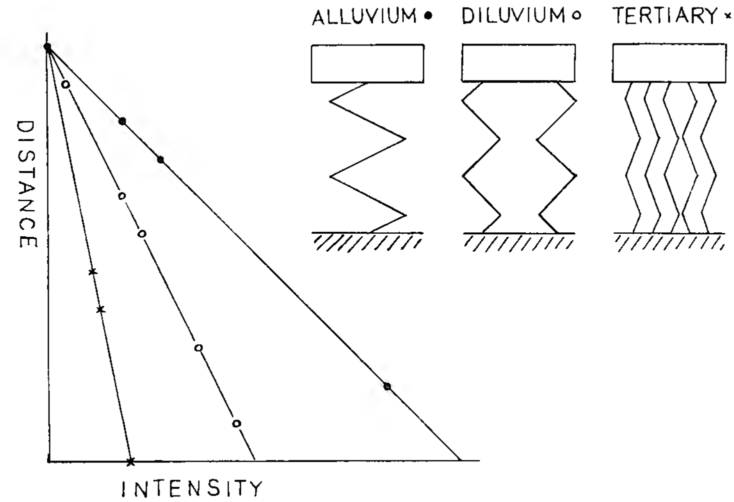

Fig. 8. The first model of mechanism of disaster distribution, that is releasing of field stress around fault.

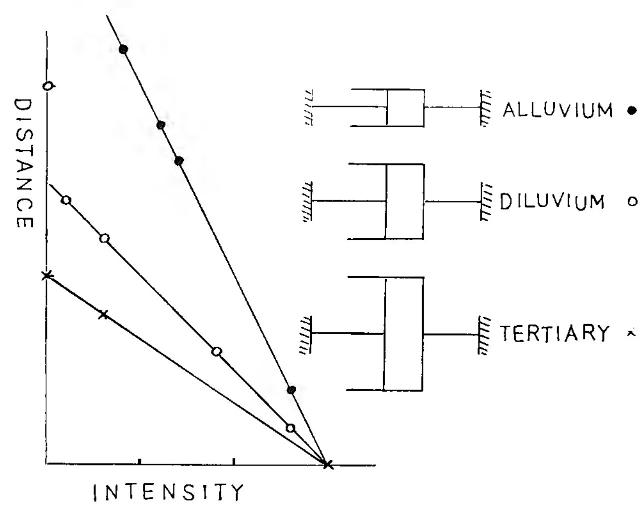

Fig. 9. The second model of mechanism of disaster distribution, that is earthquake force radiation from fault.

Table 3. The distribution of the earthquake intensity at the second model

Distance from fault Δ	0	1	2	3	4	5	6	7	8	9	10	11
Specific attenuation α	3	2	1	2	3	3	2	2	1	1	2	1
Attenuation $\alpha\Delta$	0	2	2	6	12	15	12	14	8	9	20	11
Earthquake intensity	15	13	13	9	3	0	3	1	7	6	0	4

The second model explains the mechanism of the distribution of the earthquake intensity more suitably than the first model.

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