25. *On the Nature of Earthquakes Studied by Means of the Seismic Wave Analyser.**

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It is not seldom taken, even in these days of the development of the seismology, that seismic waves start from a very narrow region, if not a single point, of the earth crust. From the inference that the tremendous energy of an earthquake cannot be given out from a very limited region, one might be convinced of the incorrectness of such a view. This may partly be attributed to the inadequacy of detecting successive fresh waves, even if exist, out of an ordinary seismogram, since their presence is masked by the trail of the pioneering shock. The writer's seismic wave analyser which works under the principle of selective resonance seems to be competent for the study of the nature of an earthquake in this connection.

From the observations made with this instrument the present writer found that, (1) the district where our laboratory stands had a natural frequency of vibration of 0.3 sec., (2) whenever a near earthquake in which, as a rule, quick vibrations are predominant was recorded by the analyser, the pendulum having the natural period of oscillation of 0.3 sec. oscillated most forcibly. These facts together with the construction of the instrument were reported in this Bulletin[1]

From the record given by this instrument the number of shocks in an earthquake can be detected, except when the shocks emanate simultaneously from a narrow region or continuously one after another from an extended region. This analysis cannot be made out of an ordinary seismograph for the reason described above.

Since the completion of the instrument 16 earthquakes were successfully recorded, which had the epicentre lying within a distance of 100 km. from our laboratory and were of the intensity of 4 and above (according to the Rossi-Forel scale). It is to be regretted that the construction of the instrument does not admit to record a feeble earthquake. The number of groups

* An outline of this paper was published in *Proc. Imp. Acad.*, **4** (1928), 2.

1) K. SUYEHIRO, *Bull. Earthq. Res. Inst.*, **1** (1926), 59–64.

Table.

No.	Date	Groups of waves	Epicentre	Distance between alleged epicentres	Focal depth	Remark
1	April 18, 1926	5	(o) Kawawa	—	(o) 25 km.	See Fig. 1.
2 (Deep origin)	April 27, 1926	1	(o) Tokyo Bay	—	(o) 55 „	See Fig. 2.
3	Jan. 9, 1927	2	(F) Akabane (o) Urawa	15 km.	(F) 35 „ (o) 30 „	One group was conspicous and the other very feeble
4 (D.o.)	Feb. 25, 1927	5	(F)(o) Anegasaki	0 „	(F)(o) 60 „	
5	May 20, 1927	4	(F)(o) Titibu	0 „	(F) 45 „ (o) 35 „	(M)
6 (D.o.)	May 26, 1927	5	(F)(o) Nagareyama	0 „	(F) 75 „ (o) 70 „	
7	Aug. 7, 1927	11	(F) Off the Tiba Coast (o) Inbanuma	20 „	(F) 55 „ (o) 40 „	
8	Aug. 8, 1927	3	(F) Yokosuka (o) Yokohama	20 „	(F) 45 „ (o) 50 „	
9	Sept. 5, 1927	8	(F)(o) Kakioka	0 „	(F) 45 „ (o) 50 „	(M)
10	Sept. 6, 1927	3	(F)(o) Mt. Tanzawa	0 „	(F)(o) 45 „	
11	Sept. 7, 1927	6	(F) Kawagoe (o) Suikaido	45 „	(F) 30 „ (o) 40 „	
12	Sept. 13, 1927	5	(F) Kitaura (o) Namekawa	25 „	(F) 35 „ (o) 30 „	See Fig. 3.
13 (D.o.)	Oct. 25, 1927	1	(F) Futu (o) Off the Kisarazu Coast	15 „	(F)(o) 55 „	See Fig. 4. Three minor groups followed
14	Sept. 7, 1927	4	(F) Suikaido (o) Sekiyado	20 „	(F) 40 „ (o) 20 „	
15 (D.o.)	Sept. 18, 1927	1	(F) Atuki (o) Ofuna	20 „	(F) 80 „ (o) 85 „	See Fig. 5.
16 (D.o.)	Dec. 31, 1927	2	(F)(o) Noda	0 „	(F)(o) 95 „	(M)

of seismic waves, which may possibly be the number of the shocks (revealed by the 0.3 sec. pendulum), together with the spicentres and the focal depths found from ordinary seismogram are given in the table; needless to say, the latters refer to the pioneer shocks.

In this table the epicentres and focal depths marked (F) were estimated from the ratio of the durations of the preliminary tremor observed at four different stations favourably situated, and those marked (o) estimated from the same durations observed at three stations applying Omori's constant (7.42 km/sec.). With regard to the source of informations, those marked (M) were taken from the observations of the Meteorological Observatory, and the rest from those of this Institute.

The epicentres given by (F.) are shown in the accompanying map (Fig. 6), classifying the focal depths into two kinds, one of which had the depth more than 50 km and the other less than that. This classification is not quite arbitrary; according to the investigations by Wadati,[2] a discontinuity of the earth crust known under the name of A. Mohorovičić seems to exist in our island at a depth of 45 km. or so.

From the table it will be seen that the earthquakes of shallow origin ($<$50 km.), except only No. 3, showed a number of groups of waves (see Figs. 1, 3), while most of those of deep origin ($>$50 km.) had only one or two groups (see Figs. 2, 4, 5). These facts seem to suggest that the nature of the breakdown of the earth crust varies in different strata; in the upper stratum where the rock is probably brittle, the breakdown starts one after another or simultaneously at different spots, while in the lower stratum where the rock is possibly plastic, the breakdown occurs all at once on a limited region. Although the writer does not dare to push the inference unreasonably so far as to apply the result of an ordinary engineering strength test[3] directly to the breakdown of the earth crust, yet the fact that generally the breakdown of the granite proceeds gradually while that of basaltic rocks occurs suddenly, may be suggestive in this connection.

It is worthy of notice that in computing the focal depth and also in estimating the position of the epicentre of deep earthquakes either method (F) or (o) gives practically the same value, while those of some shallow earthquakes the waves of which are composed of several groups give irreconcilable values according to the different methods of computation (refer to Nos. 7, 11, etc. in the table). This seems to suggest that the breakdown

2) K. Wadati, *J. Met. Soc. Jap.*, [ii], 3 (1926), 8.

3) An experiment on the strength of stones carried out by Prof. K. Yuasa at the writer's request, the result of which will be reported elsewhere.

of the crust near to the earth's surface does not occur all at once on a narrow region, but probably takes place at different spots either simultaneously or succeessively, and accordingly there is every possibility that those shocks which are taken as the initial wave at different stations are not necessarily of one and the same origin.

On the other hand, in the case of those waves starting simultaneously at different spots only those originating nearest are observed at the stations closest to them respectively. Thus the depth and the epicentre estimated as if the wave originates at a single point are rather misleading, and consequently a full consideration of the extent of the origin is quite necessary in estimating them.

The only way of finding the extent of the origin is to draw the exact isochronous lines of earthquakes. Thus, apart from the importance for other purposes, an exact chronography seems to be urgent for finding the correct informations of an earthquake.

In concluding this paper the writer wishes to thank Mr. W. Inoue and Mr. R. Takahasi for their trouble taken in computing the informations given in the table.

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25. 振動分解器による地震の性質の研究

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（昭和三年十月十六日發表　昭和四年十月二九日受理）

今日でも尙地震波は地殻の一點から起る樣に考へらるゝ事が稀れではないが、是れは普通の地震計の記象は、最初に起つた振動を明示し得るのみに止まり、夫れのみに就き研究を爲す習慣があるから、自然前記の樣に考へられる事が無理ではないと思はれる、著者は振動分解器の記錄により、地震波の群を觀測して、次の事柄を示してゐる。

（1） 地震波は普通一個所から起るものではない事。

（2） 隨て所謂震央は、觀測をなす地點により、異なる位置を取り得る可能性ある事。

（3） 著者の觀測の範圍では、深い地震と淺い地震とは、地震群の數に差異ある事實。

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

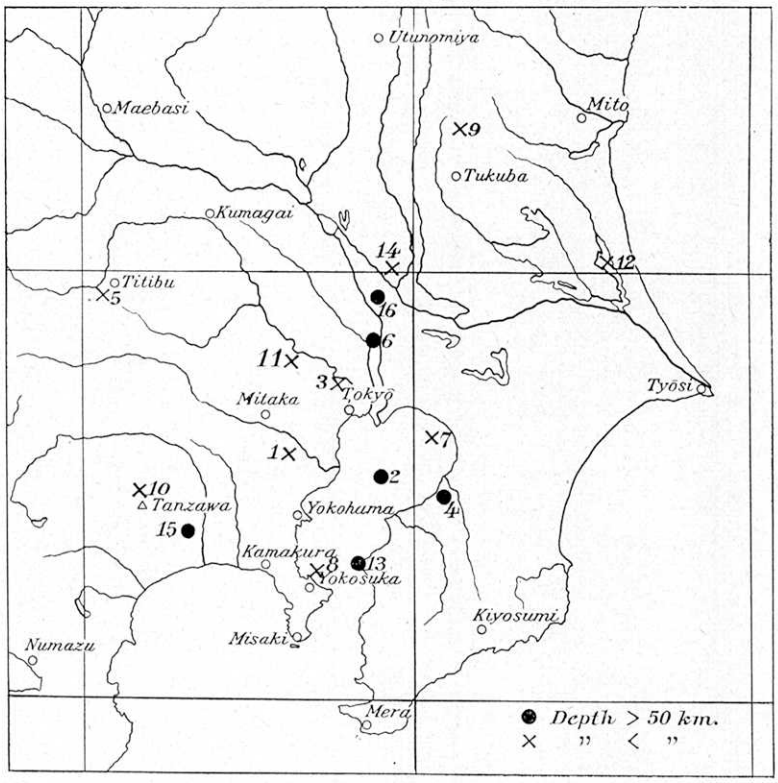

Fig. 6.

（震研彙報、第七號、圖版、末廣）