On the Estimation of the Time of Occurrence at the Origin of a Distant Earthquake from the Duration of the 1st Preliminary Tremor observed at any place.

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The approximate time of occurrence ($=t_0$) at the origin of a distant earthquake can be calculated from the duration of the 1st preliminary tremor ($=y_1$) of the latter observed at any place. Thus, let T denote the time interval taken by the initial vibrations of the earthquake motion in travelling the arcual distance ($=x$), between the origin and the given station; and let v_1 and v_2 denote the velocities of propagation corresponding to the 1st and 2nd preliminary tremors. Then we have:—

$$v_1=\frac{x}{T};\ v_2=\frac{x}{T+y_1};\ \frac{v_1}{v_2}=1+\frac{y_1}{T}.$$

Putting proper values for v_1 and v_2, namely, $v_1=13.7$ and $v_2=7.2$ km. per sec.*, we obtain:—

$$T=1.108\ y_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The values of v_1 and v_2 used in deducing the above formula are those obtained by "difference method," that is to say, calculated by taking the differences of the epicentral distances of different observing stations, and the differences of the times of arrival at the latter of the earthquake motion. For our present purpose,

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* These values are slight modifications of those given in the "Publications," No. 13.

however, it is perhaps better to take the values of the transit velocities deduced by "direct method", or those obtained by dividing the epicentral distance of a station by the time interval taken by the seismic waves in traversing that distance.‡ The results deduced from the observations of the Indian earthquake of April 4, 1905, at different seismological stations, are as follows* :—

$$v_1 = 10.6 \quad \text{km. per sec.;}$$
$$v_2 = 5.83 \quad \text{,,} \quad \text{,,}$$

Using these values we obtain :—

$$T = 1.222\, y_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Let us provisionally take the mean of the two equations, thus:—

$$t_0 = t_1 - 1.165\, y_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

in which t_1 denotes the time of commencement of the earthquake motion at a given observatory.

Equation (3), which is to be regarded as being roughly approximate, gives fairly good results, as shown by the following examples.

(1) *Indian Earthquake of April 4, 1905.*

The time($=t_1$) of occurrence in Tokyo of this earthquake was $0^h\ 59^m\ 13^s$ (G. M. T.); the duration ($=y_1$) of the 1st preliminary tremor being 7m 16s. From (3) we thus find, for the time of earthquake occurrence at the centre itself:—

‡ See next Article.

* Deduced from the observations at the different stations, whose epicentral distance varied between 20° and 120.°

$$t_0 = 0^h\ 59^m\ 13^s - (1.165 \times 436^s) = 0^h\ 50^m\ 45^s \text{ (G. M. T.)}$$

This agrees very well with the time of occurrence at the origin inferred from the magnetograph observations made at Dehra Dun, namely, $0^h\ 49^m\ 48^s$ (G. M. T.)

(2) *San Francisco Earthquake of April* 18, 1906.

The time (t_1) of occurrence in Tokyo was $5^h\ 24^m\ 35^s$ A.M. (in Western States, or Pacific, Time); the duration ($=y_1$) of the 1st preliminary tremor being $9^m\ 49^s$. For the time of occurrence at the origin itself, we have:—

$$t_0 = 5^h\ 24^m\ 35^s - (1.165 \times 9^m\ 49^s) = 5^h\ 13^m\ 5^s \text{ A.M.}$$

This seems to be very close to the real value of t_0, since the time of occurrence of the great earthquake observed at the Students' Observatory, Berkeley, and Lick Observatory, Mount Hamilton, were respectively $5^h\ 12^m\ 39^s$ and $5^h\ 12^m\ 12^s$, these two places being not much distant from the epicentral zone. The time of earthquake occurrence at the centre of disturbance was probably $5^h\ 12^m$.

(3) *Calabrian Earthquake of Sept.* 8, 1905.

The time (t_1) of occurrence in Tokyo of the seismic motion was $1^h\ 56^m\ 09^s$ (G.M.T.); the duration (y_1) of the 1st preliminary tremor being $10^m\ 25^s$. Applying these values to our formula, we obtain:—

$$t_0 = 1^h\ 56^m\ 09^s - (1.165 \times 625^s) = 1^h\ 44^m\ 00^s \text{ (G.M.T.)}$$

Now according to the seismographical observations made at the Observatory of Messina, the earthquake shock was felt there first at

$1^h\ 43^m\ 17^s \pm 2^s$ (G.M.T.). Hence the time of occurrence at the origin itself was probably about $1^h\ 43^m\ 00^s$, which is close to the result estimated above.