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ESTIMATION OF LOCAL MAGNITUDE (M_L) FROM SIGNAL DURATION RECORDS OF W. W. S. S. N., SHILLONG

In recent years signal duration from high gain seismographs are being frequently used for estimation of local magnitude, M_L. This is done because of difficulties in calculation of magnitude due to amplitude traces of seismic waves becoming white for high magnitude events due to faster movement of light spot and non-recording of low magnitude events on photographic records of Wood-Anderson seismographs due to its normal low gain. Dube and Ramachandran (1989) presented empirical equations for estimation of local magnitude, M_L, from signal duration records of Benioff short period vertical component of W.W.S.S.N., Shillong.

Galvanometers of the W.W.S.S.N. were replaced by electronic amplifiers in January 1988 and recording of earthquakes commenced by heated stylus arrangement. The magnification was reduced from 200 K at 1 sec to 100 K. The instrumental constants are as under :

Free period of seismometer = 1 second,
Damping = Critical,
Magnification = 100 K at 1 second,
Filter setting = 0.01 Hz — 1.34 Hz.

Since signal duration is known to be dependent on instrumental response of seismograph in addition to other factors like geology, azimuth of the station from location of epicentre, (Rao and Nag 1981) it is considered necessary to calibrate the signal duration record of the short period vertical component of W.W.S.S.N., Shillong, with local magnitude, M_L, evaluated from Wood-Anderson seismograph inview of the change in instrumental constants as stated above. Results of this calibration are reported in this work.

2. Local magnitudes, M_L, for 110 earthquakes during the period January 1988 to March 1989 originating within and around Shillong plateau and within magnitude range of 1.7 to 6.2 were evaluated from the Wood-Anderson seismogram of Shillong Observatory making use of nomogram of Guttenberg and Richter. The epicentral distances of these events varied between 10 km to 600 km. Corresponding signal durations in seconds for all the 110 earthquakes were determined from the seismograms of the short period vertical seismograph of the W.W.S.S.N. Signal duration used here is the duration in seconds of earthquakes records on seismograms from the onset time of *P*-arrival till the seismic waves merge with the background level. This is generally 1.5 mm for the Shillong Observatory.

An equation given below, which has been used by many workers (Lee *et al.* 1972; Real and Teng 1973; Rao and Gupta 1979, Dattatrayam and Srivastava 1988, Dube and Ramachandran 1989) is proposed to be used to obtain empirical equation between signal duration and local magnitude.

$$M_L = a + b \log \tau + c\Delta \qquad (1)$$

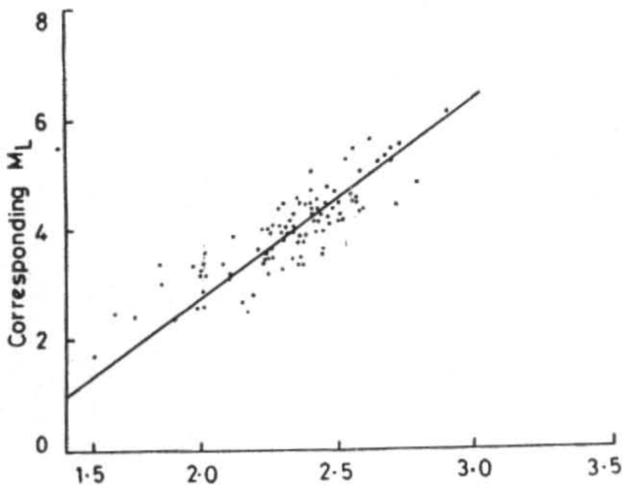

Fig. 1. Local magnitude *versus* log τ

TABLE 1

Correlation coefficient between local magnitude M_L and estimated magnitude from signal duration

Authors	Correlation coefficient	Standard error
Present study	98.00	0.37
Rao and Nag	87.25	0.55
Dattatrayam and	Model II 74.19	0.57
Srivastava (1988)	Model III 81.59	0.56

TABLE 2

Comparison of local magnitude M_L with estimated magnitude from signal duration

Date (1989)	Epicentral distance (km)	Signal duration (sec)	M_L (Richter (scale)	M_L Esti-mated	USGS data (MB)
9 Apr	516	950.0	5.6	5.4	5.2
18 May	255	350.0	4.9	4.5	4.8
22 May	403	600.0	5.0	4.9	5.0
12 June	445	1228.0	6.1	5.7	6.0

where M_L is the local magnitude, τ the signal duration in seconds, $\triangle$the epicentral distance in km, a, b and c are constants. In order to estimate the dependence of signal duration (τ) on epicentral distance ($\triangle$), straight line equations ($\log \tau = a + b\ \triangle$) as given below have been obtained by the method of least squares :

$$\log \tau = 2.2959772 + 0.0004611\triangle;\ M_L = (3.5 \text{ to } 4.0) \quad (2)$$

$$\log \tau = 2.4519919 + 0.0002567\triangle;\ M_L = (4.0 \text{ to } 4.5) \quad (3)$$

It is seen from the above equations that the values of constants are not differing much and therefore it is presumed that the dependence of log τ on the epicentral distance will not change significantly with the change in magnitude. Similar observations were made by Dube and Ramachandran (1989). Inview of above, average of the constants has been adopted and the equation as obtained is given below :

$$\log \tau = 2.3740 + 0.0003589\triangle \quad (4)$$

The effect of epicentral distance on log τ has been removed by making use of the above equation for all the M_L of 110 earthquakes. The values of log τ so obtained have been plotted against M_L in Fig. 1 and empirical equation obtained by the method of least squares is given below. It is represented as solid line in Fig. 1.

$$M_L = 2.4720 \log \tau - 1.7636 \quad (5)$$

Thus the final empirical equation obtained to evaluate local magnitude M_L from signal duration record is as given below. It is proposed to use this equation for estimation of local magnitude.

$$M_L = 2.4720 \log \tau - 0.0003589\triangle - 1.7636 \quad (6)$$

Uncertainty in determining magnitude has been estimated by

$$\sigma = [\sum_{i=1}^{n} (M_L - M_T)^2/(n-1)]^{1/2}$$

It is found to be ± 0.37.

It is mentioned here that Dube and Ramachandran (1989) obtained the empirical equations given below :

$$M_L = 2.11418 \log \tau + 0.0001241\triangle - 1.4574\ ; \quad 2.0 \leqslant M_L \leqslant 4.7 \quad (7)$$

$$M_L = 1.13616 \log \tau + 0.0001241\triangle + 1.9818\ ; \quad 4.8 \leqslant M_L \leqslant 5.9 \quad (8)$$

It is seen that the values of constants in Eqn. (6) are different than those in Eqns. (7) and (8) of Dube and Ramachandran (1989) and therefore support the views of Rao and Nag (1981) that signal duration is dependent on instrumental response.

In order to have a picture with regard to goodness in relationship between M_L and magnitude estimated from signal duration record in the present study, correlation coefficient (R) has been calculated and is presented in Table 1. Correlation coefficient obtained by other workers (Rao and Nag 1981; Dattatrayam and Srivastava 1988) are also presented for comparison. It is seen that the goodness in relationship is comparatively better in this study.

3. Magnitude of few earthquakes, data for which has not been incorporated in the present study, have been calculated with the empirical formula obtained in Eqn.(6) and compared with U.S.G.S. data. The values so obtained are given in Table 2. It is observed that the estimated M_L values and corresponding observed values are in good agreement with each other.

In view of what has been described in the foregoing it is suggested that Eqn. (6) may be used for estimation of local magnitude from signal duration records of short period vertical component of W.W.S.S.N. Shillong.

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