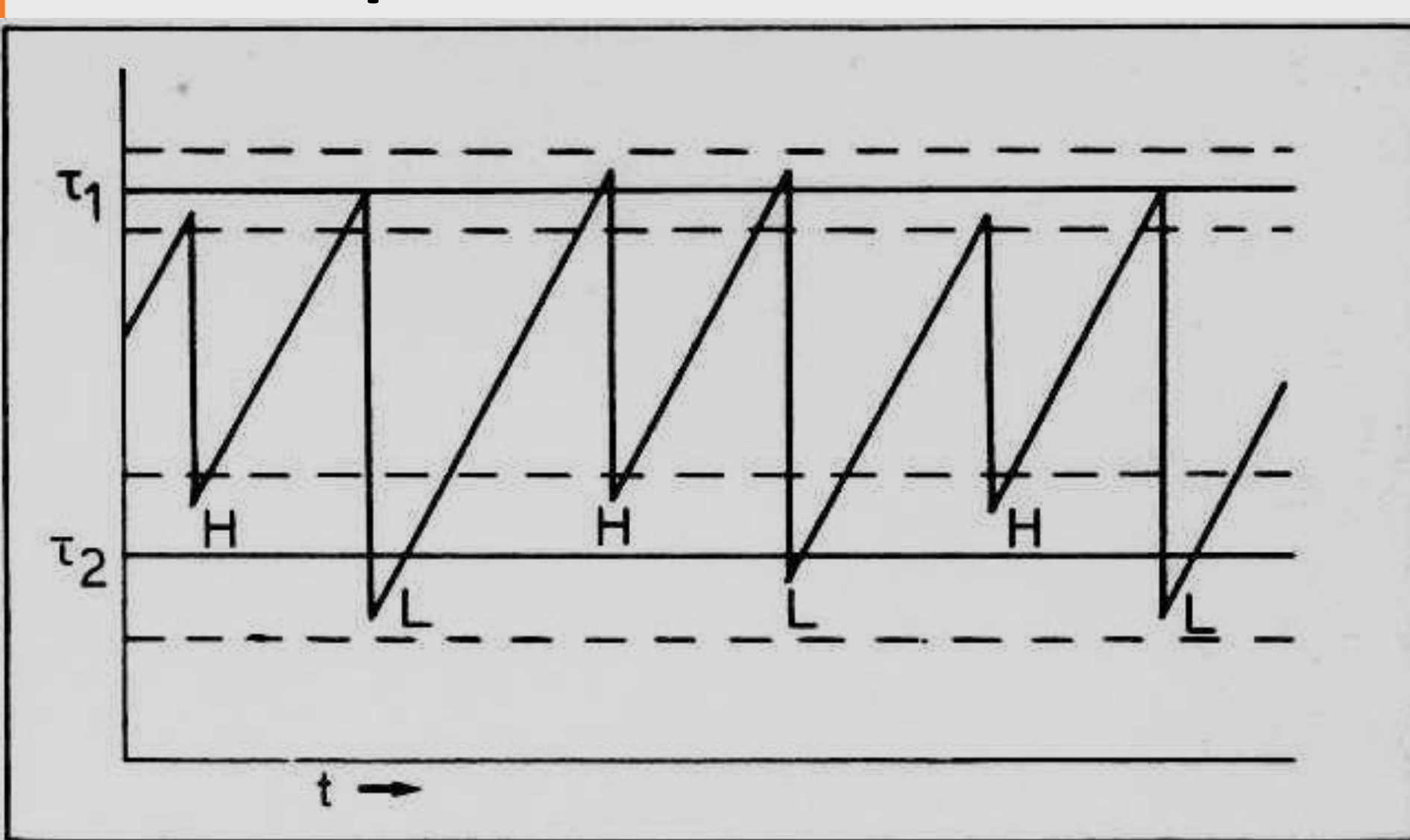


## Abstract

The Himalayan region, the zone of collision of the Indian and Eurasian plates is most earthquakes prone. Based on the observed positive correlation between the inter-event times and the magnitude of the preceding mainshocks, the time- and magnitude- predictable model is found to be applicable in study region. The earthquakes with magnitude  $M_s \geq 5.5$  since 1906 to 2008 occurred in 19 delineated seismogenic sources in northeast India Himalaya have been used to predict the future earthquake hazard. It is found that, the probabilities for the occurrence of moderate to large size earthquakes in some of the seismogenic sources of northeast India and its adjoining southeastern Tibet is significantly high ranging from 0.81 to 1.0 for the next decade. Using the estimated conditional probabilities for occurrence of moderate to large size earthquakes, we report that eight such earthquakes of expected magnitude range 6.0-7.1 would occur till 2019 of which six will be located in Arakan-Yoma region (three intermediate and three shallow) and remaining two shallow focus one each in the Himalayan Frontal Arc and the Eastern Syntaxis. It has been advocated that these vulnerable seismogenic sources be monitored for multi-hazards in real time for future development and planning.

**Introduction:** Nowadays, earthquake hazard is perceived differently than one or two decades ago due to occurrence of unexpected large earthquakes. Although there is no unique method for the estimation of earthquake HAZARD, statistical models are popular among researchers. Among these, Most of the studies related to seismicity and seismic hazard assessment are based on time-independent models (Papazachos et al., 1994. The time-independent models assume that seismicity does not change with time but only with space.). These models are based on the Poission distribution for time and Gutenberg-Richter formula for magnitude distribution. The researchers worked for and searched for a time-dependent seismicity model to fulfil the limitations and inadequacy of independent models. During the last three decades, several attempts have been made to assess time-dependent seismicity models. This attempt led to the conclusion that repeat times for earthquakes occurring in single fault or plate boundaries support time-predictable models. Two time-dependent seismicity models have been proposed by Shimazaki and Nakata (1980); the slip-predictable model and the time-predictable model.

## Model Representation:



Time variation of stress in a seismogenic sources for the model proposed and assumes that stress is accumulated at a constant rate (inclined lines are paralel) and is release during the generation of the mainshock. The maximum stress  $t_1$ , value fluctuate within a relatively narrow stress interval and the minimum stress,  $t_2$ , values fluctuate within a considerably broader interval.. The minimum stress values, however, follow a statistical law according to which low values (L) are typically followed by high values (H) and vice-versa.

## Regional Time and Magnitude Predictable Model (Papazachos, 1997)

$$\log T_t = b M_{min} + c MP - d \log m_0 + q \quad (1)$$

$$M_f = B M_{min} - C MP + D \log m_0 + m \quad (2)$$

where  $b, c, d, q, B, C, D, m$  are the parameters of this model

- The term **bMmin** shows that larger the threshold magnitude, the larger repeat times in the seismogenic region
- The term **cMp** shows that the larger the magnitude of mainshock in a seismogenic region, the longer time up to the next mainshock
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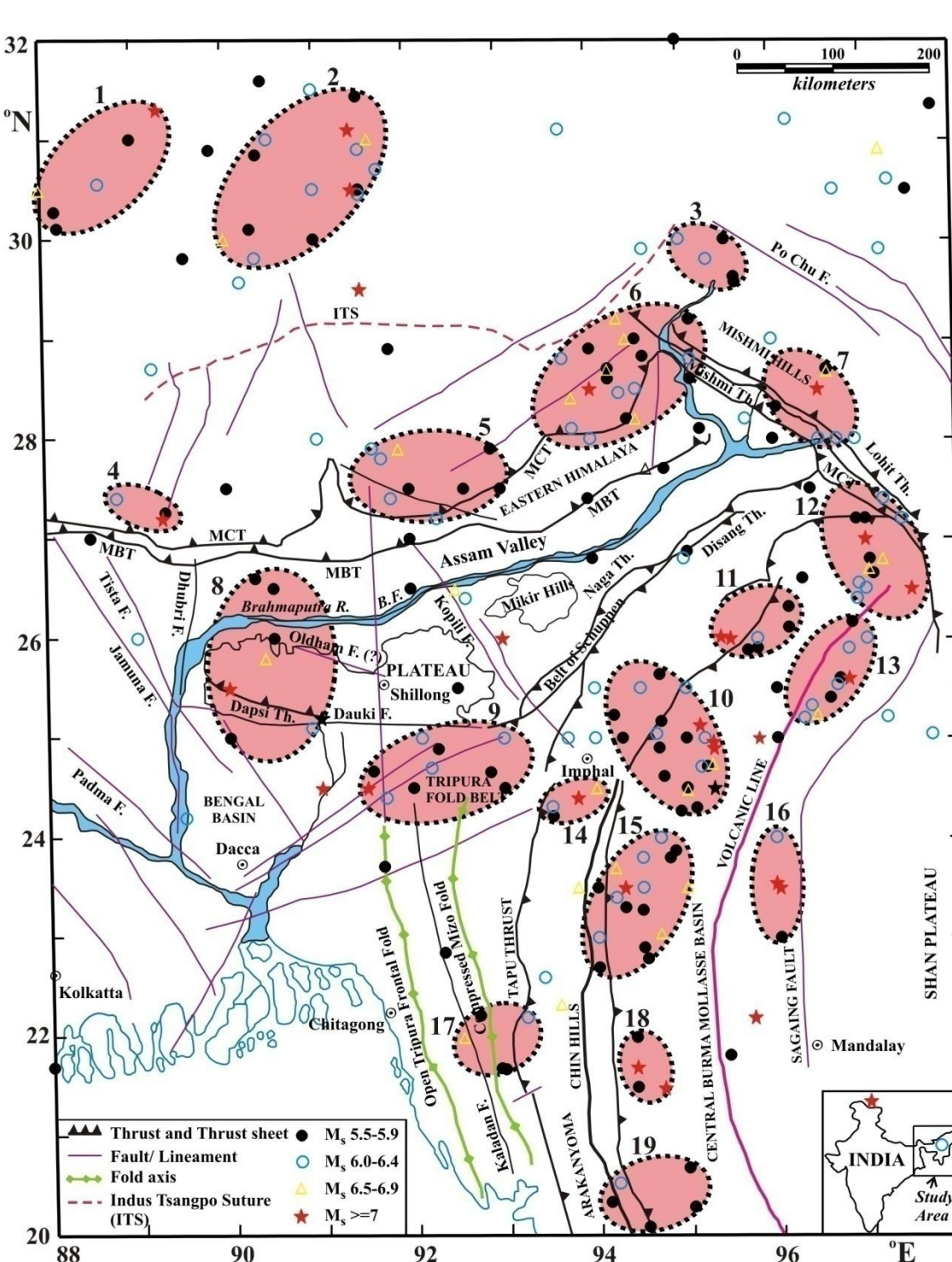
we can estimate Earthquake Occurrence Probability and magnitude of the expected strong mainshocks (Hazard) in the seismogenic region

## Estimation of the Conditional probabilities for the expected mainshocks :

Probability,  $P$ , for the occurrence of mainshock with  $M \geq M_{min}$  during the next  $\Delta t$  years when the previous such earthquake occurred 't' years ago (From Now): and,  $F$  is the complementary cumulative value of the normal distribution with mean equal to zero and standard deviation equal to  $\sigma$

$$P(\Delta t) = \frac{F\left(\frac{X_2}{\sigma}\right) - F\left(\frac{X_1}{\sigma}\right)}{1 - F\left(\frac{X_1}{\sigma}\right)}$$

$$X_2 = \log\left(\frac{(t + \Delta t)}{T_t}\right) \quad X_1 = \log\left(\frac{t}{T_t}\right)$$



**Fig :** Earthquake plots with  $M_s \geq 5.5$  for the period 1906-2008 in north east India and its adjoining regions with nineteen seismogenic sources over major tectonic features of the area. The seismogenic sources are separated by shaded elliptical boundaries.

Delineated Regions	Seismo-genic sources	$M_r$	Probability (log normal)			$M_{min}$	$M_p$	$t_p$	Log $m_0$ (dyne-cm/year)
			P10	P20	P30				
Southeastern Tibet	1	5.7	0.95	0.99	1.00	5.5	5.7	1996	26.91679
	2	6.2	0.61	0.90	0.97	5.8	6.3	2008	28.29487
Eastern Syntaxis	3	5.5	0.83	0.96	0.99	5.6	5.6	2003	25.81231
	7	6.4	1.00	1.00	1.00	5.5	5.5	1985	29.12571
Himalayan Frontal Arc	4	5.8	0.88	0.97	0.99	5.6	5.6	2003	26.82221
	5	5.9	0.99	1.00	1.00	6.0	6.2	1967	26.50099
Shillong Plateau	6	6.2	0.86	0.97	0.99	5.7	5.7	2005	27.97886
	8	5.9	1.00	1.00	1.00	5.5	5.5	1960	27.19221
Arakan-yoma	9	5.6	0.94	0.98	1.00	5.6	5.6	1997	26.25809
	10	6.2	0.89	0.98	1.00	5.6	5.6	2005	28.11532
Arakan-yoma	11	6.1	0.94	0.97	0.98	6.3	7.4	1970	27.59519
	12	5.7	0.80	0.93	0.98	5.5	6.5	2000	27.57337
Arakan-yoma	13	6.3	0.93	0.98	0.99	6.1	6.2	1994	27.61581
	14	6.0	0.99	1.00	1.00	5.8	5.8	1984	27.21377
Arakan-yoma	15	5.8	0.91	0.98	0.99	5.5	5.8	2000	27.2236
	16	7.1	0.81	0.91	0.96	7.2	7.2	1991	27.95467
Arakan-yoma	17	5.6	0.85	0.96	0.99	5.7	5.9	1997	26.11876
	18	6.9	0.91	0.95	0.97	7.2	7.4	1975	27.36918
Arakan-yoma	19	5.3	0.90	0.97	0.99	5.5	5.5	1989	25.91294

**Table 2:** Estimated data of time of occurrence and magnitude of future mainshocks predicted during the next 10 years period (2010-2019).

Regions	Range of magnitude of the expected mainshock	Conditional probability ( $P_{10}$ ) for the period 2010-2019	Source zones for the location of predicted earthquakes			Predicted duration
			Sources	Area ( $\times 10^6 \text{km}^2$ )	Focal depth	
Southeastern Tibet	5.7	0.95	01	18.181	Shallow	2010-2019
Eastern Syntaxis	6.4	1.00	07	09.068	Shallow	2010-2019
	5.8	0.88	04	03.199	Shallow	2010-2019
Himalayan Frontal Arc	5.9	0.99	05	16.290	Shallow	2010-2019
	6.2	0.86	06	25.308	Shallow	2010-2019
Shillong Plateau	5.9	1.00	08	28.107	Shallow	2010-2019
	6.0	0.99	14	04.266	Shallow	2010-2019
Arakan-yoma fold belt	6.1	0.95	11	07.999	Intermediate	2010-2019
	6.2	0.89	10	18.908	Intermediate	2010-2019
Arakan-yoma fold belt	6.3	0.93	13	09.212	Shallow	2010-2019
	6.9	0.91	18	04.376	Intermediate	2010-2019
Arakan-yoma fold belt	7.1	0.81	16	06.981	Shallow	2010-2019

**Table.1:** The expected magnitude (following earthquake),  $M_f$ , and the corresponding conditional probabilities, P10, P20 and P30 for the occurrence of mainshocks ( $M_{min} \geq 5.5$ ) in northeast India and its adjoining region during the period of 2010 to 2039. ( $M_{min}$  – magnitude of the smallest mainshock considered;  $M_p$  – magnitude of the preceding mainshock;  $t_p$  – date of preceding mainshock occurred;  $m_0$  – moment rate per year)

**Conclusion:** We report that eight such earthquakes would occur till 2019 of which six will be located in Arakan-yoma region (three intermediate and three shallow) and remaining two shallow focus one each in the Himalayan Frontal Arc and the Eastern Syntaxis.

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