CHAPTER 10

SEISMIC GAP AND POTENTIAL

Spatial and temporal variations in seismicity in some seismic zone have proved useful for predicting the location and, in some instances, the time of large earthquakes. Along simple plate boundaries, where large earthquakes are known to have occurred in the past, gaps in distribution of the rupture areas for the largest earthquakes can be identified as the probable sites for future large earthquakes. This pattern was successfully applied in the seismic zone of Kamchatka and Kurile Island. The seismic gap method was applied successfully in other seismic zones by Mogi (1969), Sykes (1971), Kellagher et al. (1973) and Ohtake et al. (1977). Mc Cann et al. (1979) and Nishenko et al. (1981) have qualitatively used the term seismic potential to mean the likelihood of a region to have large or great earthquake on a plate boundary within a specified period of time. Hence, a region of high seismic potential is a seismic gap, which for historic or tectonic reasons is considered likely to produce a large shock within the next few decades. This chapter attempt to synthesize information about the potential of certain parts of northeast India for large earthquakes.

The term 'seismic gap' is used here to refer to any region along on active plate boundary that has not experienced any
large earthquakes for at least a minimum period of time, which is taken to be 30 years. The term seismic gap does not imply the potential for a large event to occur in that region. A region of high seismic potential, however, is taken here to be a seismic gap that, for tectonic or historic reasons, is thought to be capable of producing large shocks in the future.

**Seismic gap:**

The concept of seismic gap probably is applicable to shocks smaller than magnitude 7.0 mb. The initial criteria used by Kelleher et al. (1973) to determine a seismic gap were:

a) 'The segment is part of a major seismic belt characterized predominantly by strike-slip or thrust faulting'.

b) 'The segment has not ruptured for at least 30 years'.

According to Megi (1979), there are two kinds of seismic gap which are defined by two different feature of seismic activity. These two kinds of gap are termed as 'Seismic gap of the first kind' and 'Seismic gap of the second kind'. It has been found that an earthquake occurs by a sudden release of strain energy which is gradually accumulated. The largest earthquakes in the same region occur within a certain interval of each other. If there are some gaps in the spatial distribution of, rupture zones of the largest earthquakes in a seismic belt, future largest earthquakes will occur to fill the gaps. This
gap is termed as 'Seismic gap of the first kind'. According to Allen et al. (1965), Sykes (1971), Kelleher et al. (1973), gap in the rupture zone of great shallow earthquakes may be regarded as likely candidate for future great shallow earthquakes. In order to identify this seismic gap of first kind, it is necessary to examine whether gap in the spatial distribution of focal region of largest earthquakes are potential region of future largest earthquakes, using long term seismic historical data, geodetic data and tectonic setting.

The seismic gap of first kind can be identified not only for great shallow earthquakes along the plate boundaries, but also probably for some moderate size inter-plate earthquakes. Sometimes the small magnitude seismic activity in a focal region of a future large earthquake decreases prior to the large earthquake. Hence, gaps in small-magnitude earthquake activity have been noted as premonitory phenomena which is useful for prediction of earthquake. This premonitory phenomenon is termed as 'Seismic gap of the second kind'. The second kind of seismic gap may be egg-shaped or doughnut-shaped. This kind of seismic gap have been found to occur in various regions and have been discussed by a number of investigators (e.g. Kelleher and Savino, 1975; Ohtake et al., 1977; Ishida and Kanamori, 1977).

Sometimes seismic gap of the second kind may be termed as 'Seismic quiescence'. This seismic quiescence, a significant decrease in the rate of occurrence of background earthquakes below the normal rate, is one of the most promising intermediate
term precursors of large events.

The seismic gap of the first kind frequently coincides with seismic gap of second kind, but not always.

There are two subsets of seismic gaps, one 'Permanent seismic gap' and other 'Mature seismic gap' (Habermann et al., 1983). The permanent seismic gaps are segments of plate boundaries with no clear history of significant earthquakes and which, may not produce large events. Mature seismic gaps are gaps in which the observation of one or more precursors indicate that preparation for a large, gap-filling earthquake may be in progress.

From the observation of epicentral map (Figure 7) for macro earthquake for northeast India, it is found that seismic gap of first kind is almost absent in this region. But Khattri and Wyss (1978), Khattri and Tyagi (1983) and Khattri (1987) have pointed out that a seismic gap exists between the meizoseismal area of the two great Assam earthquakes 1897 and 1950. They have called it 'Assam gap'. Microearthquakes however have been found to occur within this 'Assam gap' (Chapter 6). This 'Assam gap' remain enigmatic in terms of its potential for a future large earthquake. The seismic potential remain uncertain due to inadequate seismic history in this seismic gap. This may be a permanent seismic gap of the first kind. Seeber and Ambruster (1981) do not find any gap between the epicentres of 1897 and 1950 earthquake.

Sarmah (1986) has pointed out that elliptic gaps of
various sizes may be identified in the epicentral map of north­
east India. Because of inadequate data, the seismic potential of these gaps is difficult to ascertain. The seismic gaps of the second kind are shown in Figure 34 by dotted line. The epicentre map which is used here for gap identification is the same as figure 7. The only difference is that the earthquake which occurred 30 years earlier than 1987 have not been shown in the gap regions. These seismic gaps have not been ruptured by a large shocks in the last 30 years or more.

Seismic potential:

It is probable that the seismic gap pointed here may be the potential region for a future large earthquakes. Mc Cann et al. (1979) have qualitatively used the term 'Seismic potential' to mean the likelihood of the region to have a large or great earthquake on a plate boundary within a specified period of time. Hence a region of high seismic potential is a seismic gap, which for historic or tectonic reasons is considered likely to produce a large earthquake within the next few decades. The various categories of seismic potential may be defined as follows:

(1) The region has experienced at least one large shock in the historic past i.e. more than 100 years ago (t > 100 years). This category represents the highest seismic potential.
Figure 34. Seismic gap of the second kind (elliptical and doughnut pattern)
(II) The region has experienced at least one large earthquake in the past i.e. more than 30 years ago but less than 100 years ago ($30 < t < 100$ years).

(III) The region has an incomplete history of large earthquakes but there is no evidence to indicate that a future large shock may not occur here.

(IV) The region has unusual direction of plate motion which makes it difficult to locate a gap.

(V) The region have no history of major earthquakes and tectonic evidence precludes possibility of large earthquake in future.

(VI) The region has been ruptured by a large earthquake during the 30 years ($t < 30$ years). This category is considered to represent the lowest seismic potential for the next few decades.

The conclusions about the relative seismic potential for northeast India for events with $mb \geq 7.0$ that may occur during the next few decades are shown in Figure 35. To define these categories it is necessary to have earthquake data at least for 100 years. But in northeast India, although occurrence of big earthquakes have been recorded in history book since 1548, satisfactory but incomplete data are available only from the middle of 19th century. So in northeast India it is difficult to identify a region for category I. Several regions of northeast India may be assigned seismic potential of category II.

In Eastern Himalaya tectonic unit, the blocks 3, 4, 5 and 6
Figure 35. Seismic potential of northeast India
falls under category II. The tectonic unit covering Shillong plateau, Mikir hills and adjacent area, the block 8, 10, 11 and 12 may be considered under category II. In Indo-Burma tectonic unit, the southern part i.e. block 14 may be assigned to category II. These regions require intensive study from earthquake prediction point of view.

There are some regions (blocks) which have shown incomplete history of large earthquakes. These are block 2, 9 and 13. A comparison of tectonic framework with that of other region known to be sites of historic large earthquakes may also suggest that the region is capable of being the site of a future large earthquakes. The apparent lack of historic earthquake activity necessitates placing these region in category III.

For northeast India the category IV is absent. Two regions-one on block 1 which is situated northwest of Shillong plateau and the other one on block 7 which is northeast of Mikir hills show very low seismic activity. These two regions are assigned to category V. From this study it seems that these regions may not be the sites of great earthquakes in the future.

Approximately all parts of Indo-Burma region except southern part of Mizoram are considered here as the lowest seismic potential region for the next few decades. So block 15, 16, 17, 18 and 19 are assigned to category VI.

Since the categories III and V are based on hypotheses
and not on proven fact, the assignment of region to those categories should be regarded as tentative. The degrees of seismic potential is more certain for areas that have experienced large shocks i.e. for categories I, II and VI. The categories of potential assigned here provide a rationale for assigning priorities for instrumentation, for future studies aimed at predicting large earthquakes.

Gap of source region of the largest earthquakes in a seismic belt may not always be potential regions of future earthquakes. The identified gap numbers A, B, C, G, J, K and L lie in the high potential category area and are delineated in figure 34. These gaps were the sites of large earthquakes more than 30 but less than 100 years ago (category II). They appear to have high potential for the occurrence of future large earthquakes.

From the consideration of gaps and seismic potential two regions covered by latitude 24.0°N to 26.3°N, longitude 89.2°E to 92.0°E and latitude 25.3°N to 28.0°N, longitude 92.0°E to 94.0°E as shown in Figure 36 (shaded part) may be identified as likely sites for future large event in northeast India.
Figure 36. High potential region for future earthquake