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SEISMICITY OF HIMALAYA VIS-À-VIS TECTONICS AND FOCAL MECHANISM

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ABSTRACT

The active continent- continent collision between Indian and Eurasian plates have given rise to mighty Himalaya which separates the Tibetan plateau in the north from Indo-Gangetic plain in the south. This active collision since 65 million years has produced variety of geological features in the region in the form of large thrust faults running into several thousands of kilometers and many transverse features. The region has high earthquake productivity with four great earthquakes in a span of 53 years between 1897 and 1950 and many large earthquakes. It has been found by researchers that great and major earthquakes in the Himalaya occur on the northward dipping (with a dip of about 5-10) seismically active segment of detachment (Seeber et al., 1981;Ni and Barazangi, 1984;Molnar,1990). The small and moderate magnitude earthquakes are confined in a narrow belt, referred to as Himalayan Seismic Belt (HSB), which is around 50 km wide, which may be marked by 20-30 degree dip. In this study an earthquake catalog for the past 50 years is prepared; focal mechanism of all significant earthquakes is collected from various sources and a seismo-tectonic map of Himalaya is prepared with all major features which are digitized. The seismicity is studied with respect to geological features, focal mechanism.

Keywords: Focal mechanism of Himalaya, Seismicity of Himalaya.

I. INTRODUCTION

Himalayan range extends from northwest to southeast in a 2400 kilometer stretch, separating Indo-Gangetic in south from Tibetan plateau in north.

1.1 Evolution of Himalayan Range

Indian subcontinent, a part of Gondwana island was separated from Eurasian plate by Paleotethys ocean during the late Precambrian and Paleozoic period. Pan African orogeny affected the northern part of Indian marks the unconformity between Ordovician continental conglomerates and underlying Cambrian marine sediments. The Cimmerian superterranes drifted away from Gondwana towards north. During Norian, gondwana got rifted apart in two parts- east and west. India, a part of east gondwana along with Australia and Antarctica, separated in Callovian.

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India, later broke off from Australia and Antarctica in early Cretaceous. In Upper Cretaceous, Indian plate started drifting in north direction where oceanic-oceanic subduction took place, followed by oceanic crust subducting below Tibetan block. This orogeny is active, thus many geologic relationships can be demonstrated deliberately. Collision processes have produced a variety of geologic features such as large scale thrust, strike slip and normal fault systems, widespread volcanism , regional metamorphism and formation of intracontinental and continental margin oceanic barriers.. It has been inferred that the evolution of Himalaya have played a critical role in global climate change. (Ruddiman & Kutzbach 1989, Molnar et al 1993, Quade et al 1995, Harrison et al 1998a, cf. Ramstein et al 1997)which ultimately altered the dynamics of the Himalayan-Tibetan orogenic belt(Beaumont et al 1992) and its growth (Avouac & Burov 1996). The large-scale interaction between tectonic and climate potentially makes studies of the Himalayan-Tibetan orogen of greater significance.[1] In the last three decades, many geological and geophysical investigations have been carried out in the Himalaya region, and have provided many insights into the

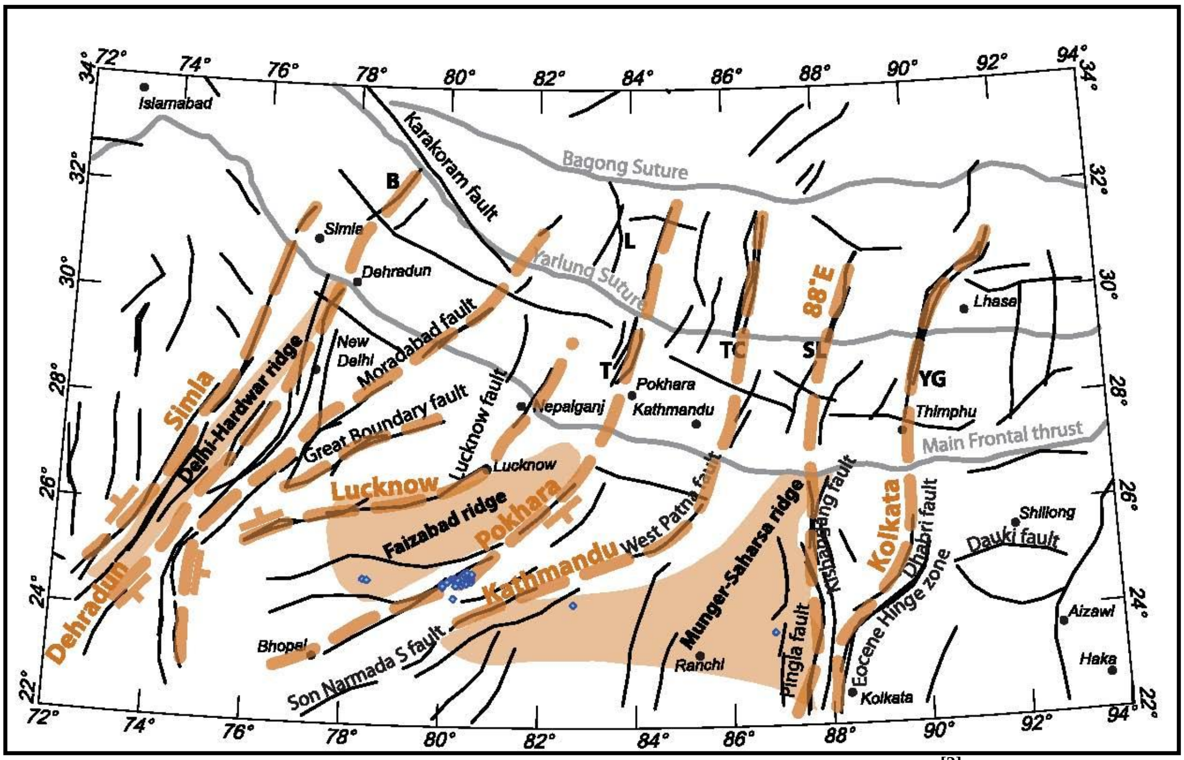

Figure 1: Ridges and Faults Across Indo Gangetic Plain[2]

overall geologic evolution of the Himalaya (Chang & Zheng 1973; Dewey & Burke 1973; Alle`gre et al 1984; Molnar 1984; Tapponnier et al 1986; Dewey et al 1988, 1989; Burchfiel & Royden 1991; Harrison et al 1992, 1998a; Molnar et al 1993; Zhao et al 1993; Avouac & Tapponnier 1993; Hsu et al 1995; Nelson et al 1996; Owens & Zandt 1997; England & Molnar 1998; Larson et al 1999; Xu et al 1998.)

There are numerous traversing faults and ridges through Himalayan range which are:

Delhi-Haridwar ridge, Faizabad ridge, Munger- Saharsa, Son Narmada fault, West Patna fault, Karakoram fault, Lucknow fault, Moradabad fault, Great Boundary fault, Dhabri fault, Pinga and Kishangarh fault.

The Delhi Haridwar ridge is the extension of Delhi Aravali fold belt. These ridges comprises of granitic and gneissic Precambrian basement rocks, trending at high angle to strike of Himalaya (Meert et al. 2010).

1.2 Stratigraphic Divisions of Himalaya

Himalaya is divided into four tectonic divisions namely, Sub-Himalaya, Lesser-Himalaya, High-Himalaya and Indus Suture Zone (ISZ). The Sub-Himalayas are composed of Miocene to Pleistocene molassic sediments, derived from erosion of Himalaya, forms its foothill. The Sub- Himalayas are still a very active orogeny, which thrusts along Major Frontal Thrust over Quaternary alluvium deposited by rivers coming from Himalaya. The Lesser Himalaya sediments thrust over sub Himalaya along Major Boundary Thrust. [3]

The High Himalayas are the areas of high topographic relief, forming the backbone of Himalayan orogeny. Sediments forming HHCS (High Himalayan Crystalline Sequence) are of late Proterozoic to early Cambrian age, comprises of medium to high grade metamorphic sequence of metasedimentary rocks.Indus Suture Zone (ISZ) marks the line of collision of Indian plate and Ladakh Batholith; and the northern limit of Himalaya.

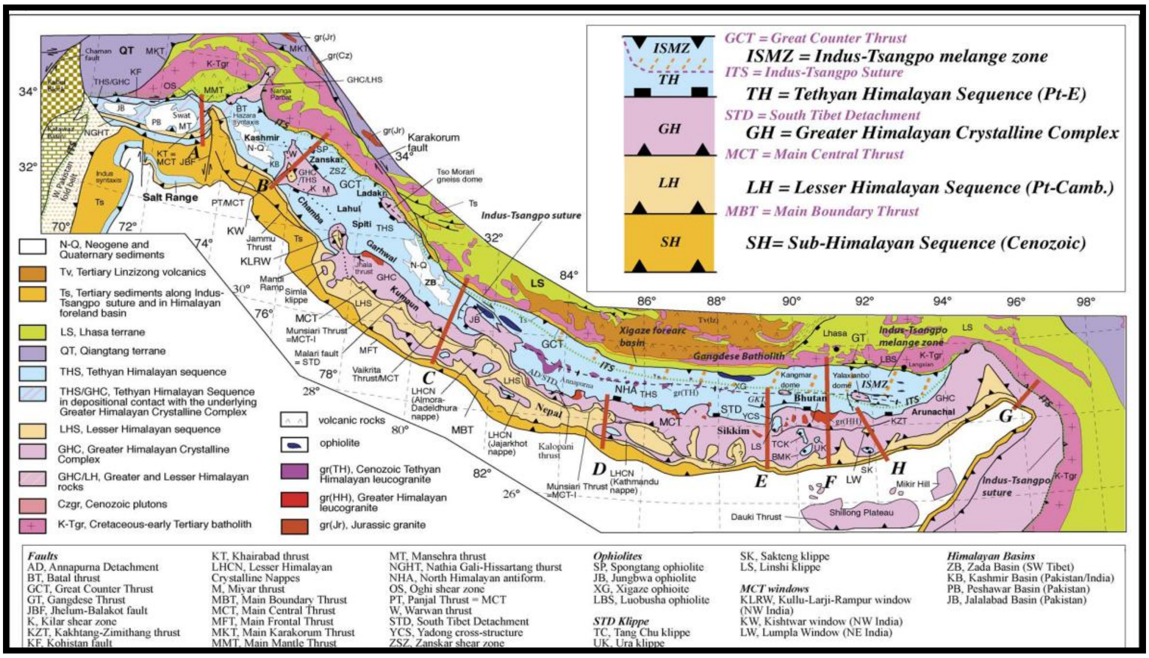

Figure 2: Stratigraphic Divison of Himalayas[4]

1.3 Seismicity

Major earthquakes occur on the northward dipping(with a dip of about 5-10)seismically active segment of detachment in Himalayas [5][6][7]. The small and moderate magnitude earthquakes which are straddling on the surface trace of MCT, are confined in a narrow belt. Himalayan Seismic Belt(HSB) is seen as the downdip edge of the locked seismically active detachment or simply the transition zone. It may be marked by 20-30 degree dipping mid-crustal ramp, between the seismically active detachment to the south and the aseismically slipping detachment to the north (Pandey et al., 1995.). The dormant character of these Himalaya thrusting at shallow depths is testified by lack of Seismicity around the exposed MBT and HFT.

The most important seismotectonic zones are:

i. Sulaiman-Kirthar Seismotectonic Belt (SKSB),
ii. Hindukush-Karakoram Siesmotectonic Belt (HKSB),
iii. Main Boundary Thrust Seismotectonic Belt (MBTSB),

iv. Himalayan Frontal Thrust Seismotectonic Belt (HFTSB),

v. Transverse Seismotectonic Zones (TSZ) viz., Aravali Range, Delhi-Haidwar Ridge, Faizabad ridge,Mongyr-Saharsa ridge,and Nawabganj Intra-cratonic High (NIH),

vi. Dauki Fault Zone(DFZ),

vii. Bengal-Arakan Seismotectonic Belt (BASB),and

viii. Deccan Intraplate Seismotectonic Zone (DISZ)

These seismotectonic belt/zones are depicted in the seismotectonic map of Himalayan region which is based on the data collected from USGS from 1964 to 2009 (Fig 3,4,5).

II. FIGURES

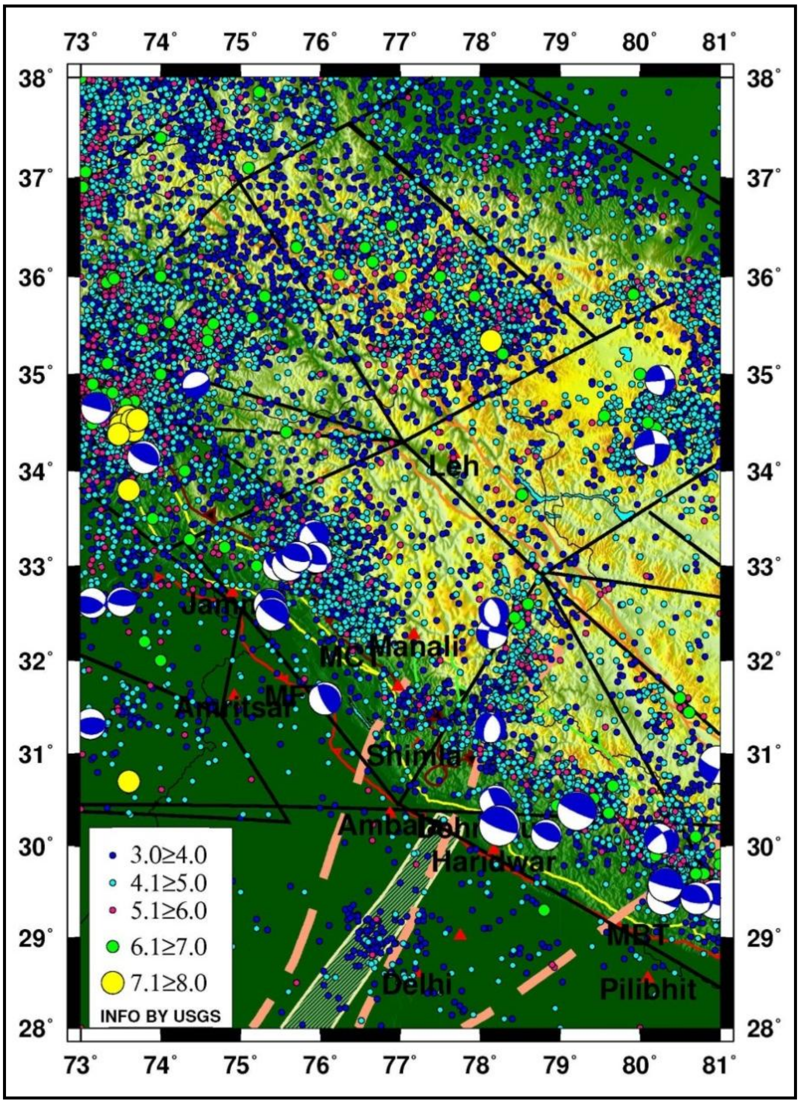

Figure 3: North Western Himalayan Region

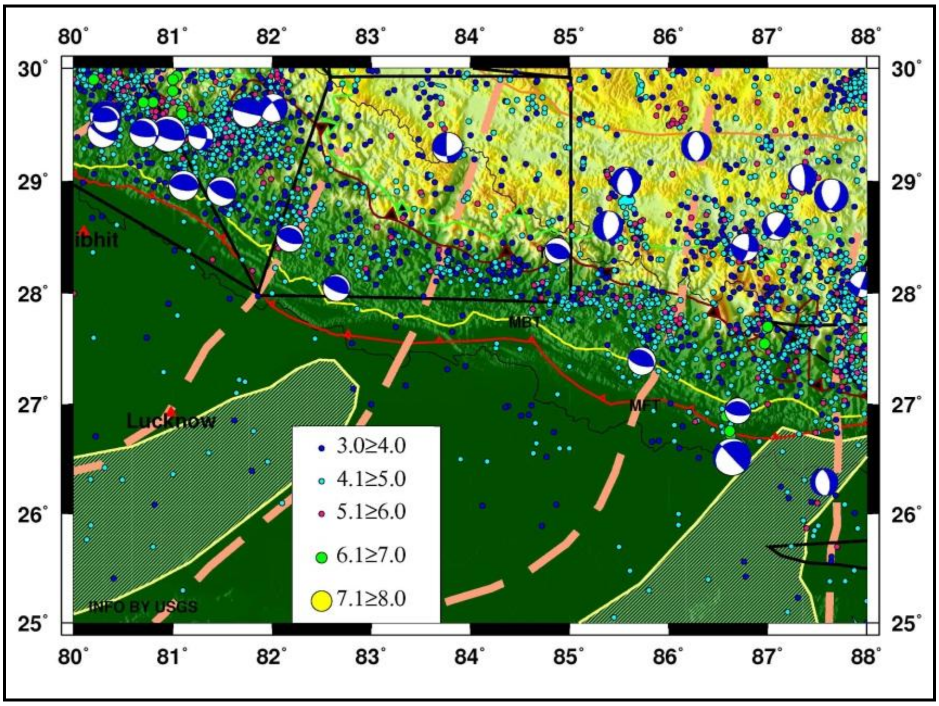

Figure 4: Central Himalayan Region

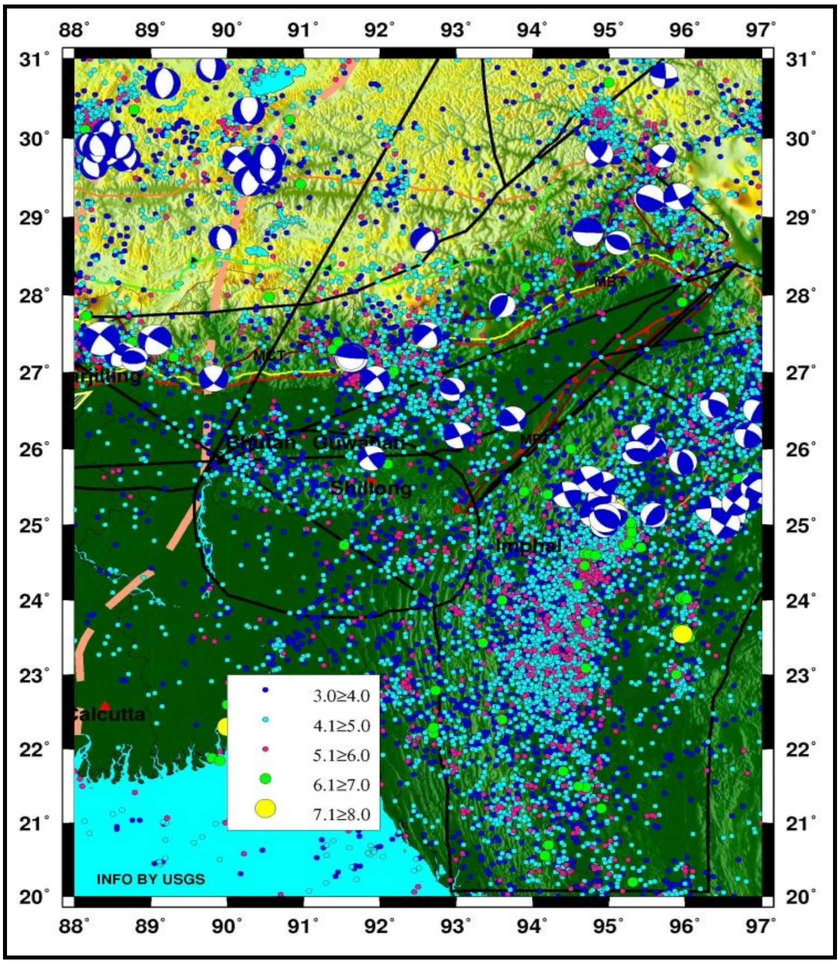

Figure 5: North Eastern Himalayan Region

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III. METHODOLOGY

This project work includes,

- Digitizing all faults along the Himalaya and transverse ridges:

  All the faults along the Himalayas namely,

  Main Frontal Thrust(MFT);

  Main Boundary Thrust(MBT);

  Main Central Thrust(MCT)

  Indus Tsangpo Suture(ITS);

  South Tibetan Detachment(STD);and

  Indus Suture Zone(ISZ).

  Major Ridges traversing along Himalayan belt, namely

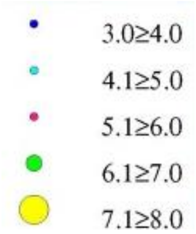
  Delhi-Haridwar Ridge;

  Munger- Saharsa Ridge;

  Faizabad Ridge.

- Collection of catalog of earthquakes and information about focal mechanism of earthquakes in Himalaya:

  Earthquake's epicenter data from 1964 till 2000 are collected and mapped. They are classified into the following divisons based on their magnitude:



- Preparing the seismo-tectonic map of Himalaya using GMT software and all available information..

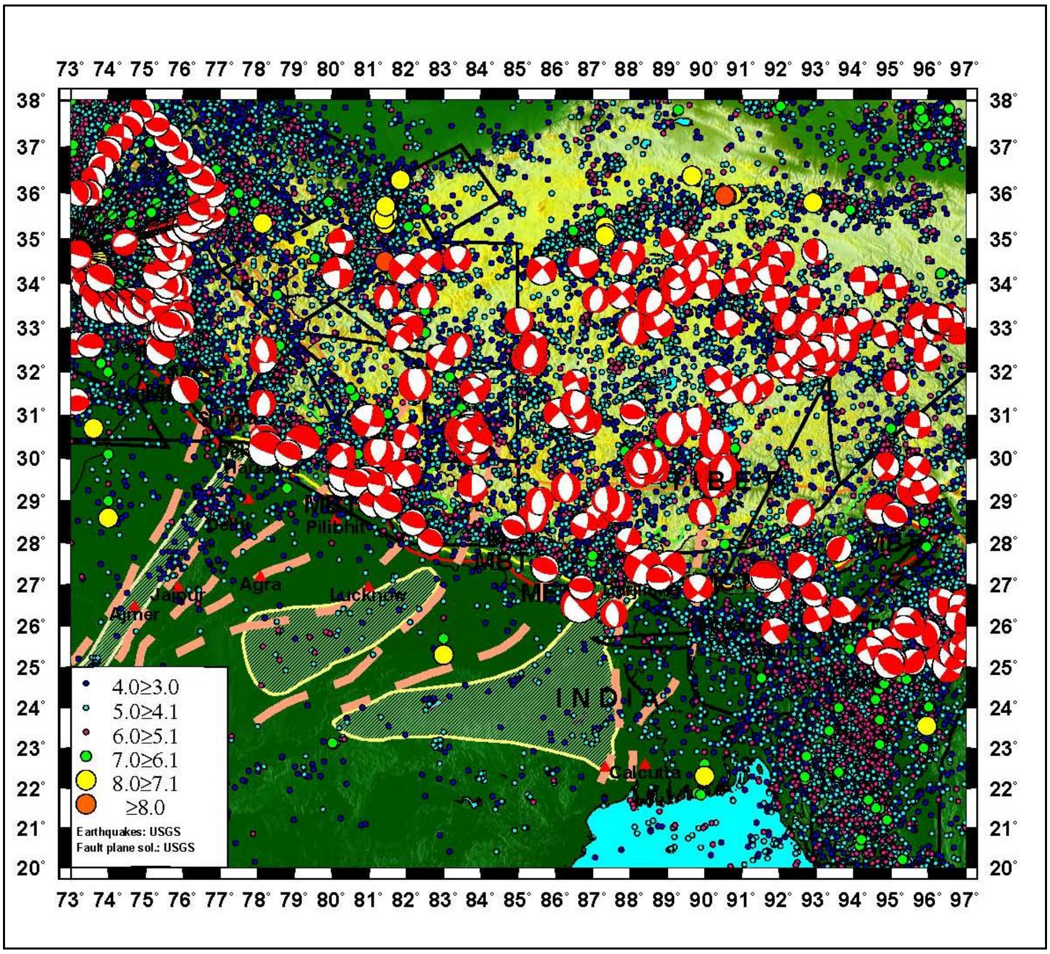


Figure 6: Himalayan Region Fault Plane Solution and Seismic Distribution

IV. CONCLUSION

Seismicity along Himalayas is primarily due to the collision of Indian and Eurasian plates. Earthquakes are concentrated all along a narrow belt called Himalayan Seismic Belt(HSB) which is around 50km wide. There is clustering of earthquakes (low to medium magnitude) along the ridges situated in Indo-Gangetic plain namely, Delhi-Haridwar Ridge, Faizabad ridge, Munger Saharsa ridge. Pamir Hindukush region homes strike slip faults and some normal faults. Large numbers of earthquakes are also observed in the north eastern Himalaya with strike slip mechanism. Earthquakes also cluster along Indo-Myanmar subduction with strike slip and few with normal fault mechanism.

The earthquake epicenters in Himalaya generally follow the srike of Himalaya with greatest concentrations of seismic activity occurring along the Hindu Kush and Pamir mountain ranges, and near the Quetta, Kashmir and Assam syntaxes. Throughout Tibet, however, the distribution of epicenters is rather irregular and no clear trends are apparent. Two aseismic lineaments, one west of the Sulaiman Range and the other in the Assam Valley, are identified. The seismic activity in the vicinity of the Counter Thrust (Indus-Tsangpo Suture zone) is rather small.

V. ACKNOWLEDGEMENT

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