SEISMICITY OF NORTH WESTERN HIMALAYA

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree
of
MASTER OF TECHNOLOGY
in
DISASTER MITIGATION AND MANAGEMENT

By

SANGEETA

CENTRE OF EXCELLENCE IN DISASTER MITIGATION AND MANAGEMENT
(CoEDMM)
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667 (INDIA)

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CANDIDATE DECLARATION

I hereby certify that the work that is being presented in this **M.Tech Dissertation REPORT**, entitled **"SEISMICITY OF NORTH WESTERN HIMALAYA"** in partial fulfilment of the requirements for the award of the Master of Technology in Disaster Mitigation and Management, submitted to the Centre of Excellence in Disaster Mitigation and Management, Indian Institute of Technology Roorkee, India, is an authentic record of my work carried out under the guidance of Dr.Amita Sinvhal, Professor, Department of Earthquake Engineering & CoEDMM, IIT Roorkee.

The matter embodied in this has not been submitted for the award of any other degree.

Sangeeta

Place: Roorkee **SANGEETA**

May 2015 13552011

CERTIFICATE

This is to certify that the above mentioned statement made by the candidate is correct to the best of my knowledge.

Amita Sinvhal

Dr. AMITA SINVHAL

Professor

Department of Earthquake Engineering & CoEDMM

Indian Institute of Technology Roorkee

Roorkee, India- 247667

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Abbreviations

EPF	East Patna Fault
GBF	Great Boundary Fault
ISZ	Indus Suture Zone
LT	Lucknow Fault
MKT	Main Karakoram Thrust
MMT	Main Mantle Thrust
MBT	Main Boundary Thrust
MFT	Main Frontal Thrust
MCT	Main Central Thrust
MSRF	Munger Saharsa Ridge Fault
MF	Moradabad Fault
NAT	North Almora Thrust
SS	Shyok Suture
SAT	South Almora Thrust
VT	Vaikrita Thrust

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ABSTRACT

The Himalayan region is one of the most seismically active regions of the world; it is part of the Alpine Himalayan seismic belt and is in a continent-continent collision zone. Strain energy is progressively accumulating in the Himalayas due to continued collision of the Indian plate with the Eurasian plate, and this energy gets released from time to time in the form of several destructive earthquakes. The amount of loss in terms of life, property and disruption of key infrastructure has been rising continuously after every earthquake.

An attempt is made to compile seismicity and tectonic data of North Western Himalaya, mostly from Seismotectonic Atlas of India and its Environs (2000), for an area between longitudes 73° – 84° E; and latitudes 25° – 36°N, for the period of 1833–1998. This large region includes the Great Kangra earthquake of 1905 in the west and the Great Bihar Nepal earthquake of 1934 in the east. It also includes 18 digitized isoseismal maps; fault plane solution of 19 thrust type, 14 strike slip and 4 normal events; and description of 19 destructive earthquakes. In addition 53 named tectonic units in the form of faults, thrusts, grabens, lineaments, fold belts, subsurface ridges, basins, syntaxes and basins are also included. This data, with more inputs, will prove useful for managing and mitigating seismic hazards.

CHAPTER 1

INTRODUCTION

The Himalayan region remains one of the most seismically active regions of the world. Due to continued collision of India with the Eurasian plate, strain energy is progressively accumulating in the Himalayas and this energy gets released from time to time in the form of earthquakes.

The Alpine belt or Alpine-Himalayan orogenic belt is a seismic belt and orogenic belt that includes an array of mountain ranges extending along the southern margin of Eurasia, stretching from Java to Sumatra through the Himalayas, the Mediterranean, and out into the Atlantic It includes the Alps, the Carpathians, the mountains of Anatolia and Iran, the Hindu Kush and the mountains of Southeast Asia.The Alpide belt is being created by ongoing plate tectonics such as the Alpine orogeny. The belt is the result of Mesozoic to Cenozoic to recent closure of the Tethys Ocean and process of collision between the northward-moving African, Arabian and Indian plates with the Eurasian plate.

Continental collision is a phenomenon of the plate tectonics of Earth that occurs at convergent boundaries. Continental collision is a variation on the fundamental process of subduction, whereby the subduction zone is destroyed, mountains produced, and two continents sutured together. Kangra Earthquake 1905, Bihar - Nepal Earthquake 1934 .

Objective

The prime concern of this study is to study the seismicity of North Western Himalaya with reference to Alpine Himalayan belt, continent-continent collision zone and great earthquake which occur in study area.

Study Area

Study area divided in 10 parts Western Himalayan Syntaxis between Kohistan Arc and Potwar Plateau, Tibetan Plateau and Kashmir Ladakh Himalaya, Trans Himalaya between Karakoram and Altyn Tagh fault, North Rajasthan and Punjab, Himachal Himalaya and adjoining Indo-Gangetic Plains, Himachal, Kumaon -Garhwal Himalaya & their Environ, North Delhi Fold belt and part of Vindhyan Basin, Indo Gangetic plains of Uttar Pradesh and uplands of Madhya Pradesh, Nepal Himalaya and Adjoining Indo-Gangetic Plains and Eastern Nepal

Himalaya and Indo-Gangetic plains of Bihar which cover latitudes 25°N-37°N and longitudes 72°E-88°E.

Method:

Studied the Seismotectonic Atlas of India and its Environs (2000) sheets from Geological survey of India.These sheets were studied for the following data.

a. Seismicity catalogue
b. Frequency distribution of earthquakes
c. Isoseismal maps
d. Fault plane solutions
e. Tectonics

Details of these sheets are given in Table 1.1, and shown in Figure 1.

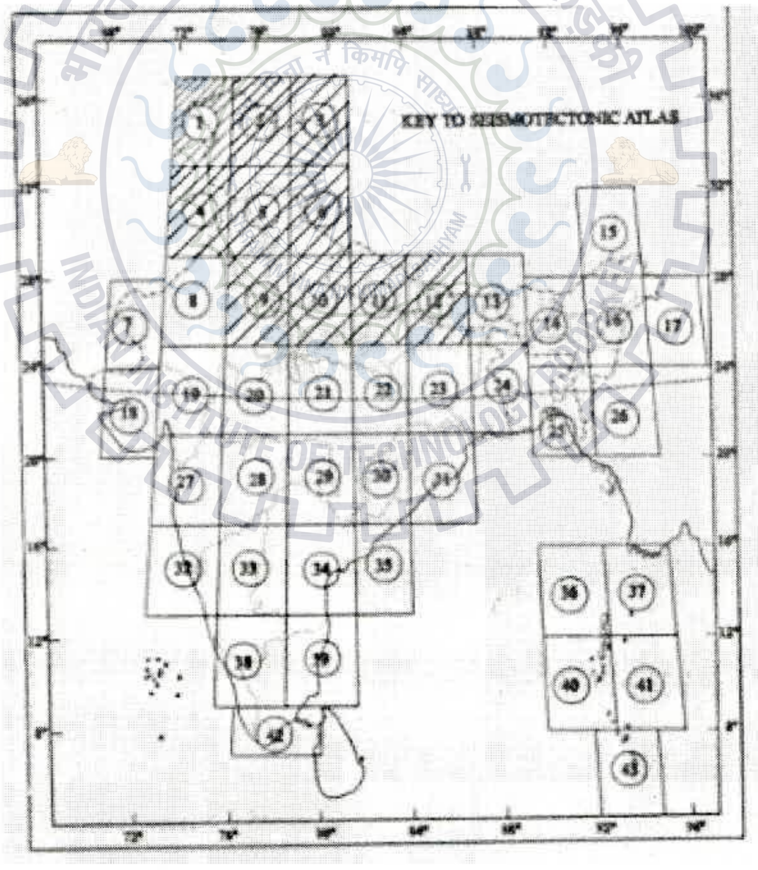


Figure 1 Highlighted portion shows study area

Table 1.1 Details of SEISAT Sheets 01-06 and 09-12 are shown in the table

SEISAT No.	Coordinates		Area	Imp physiographic features	Imp tectonic features	Magnitude range
	Latitude	**Longitude**				
1	72^oE - 75^oE	33^oN - 37^oN	Western Himalayan Syntaxis between Kohistan Arc and Potwar Plateau	Great Karakoram Range, Hindukush Mountain, Kashmir basin, Pamir Plateau, Peshawar basin, Potwar Plateau **Rivers:** Abi Panja, Chenab, Indus, Jhelum, Mastuj	Attock fault, Frontal belt, Jhelum fault, Main Boundary Thrust, Main Karakoram Thrust, Main Mantle Thrust, Peshawar fault, Tarbela Fault, Shinkiari fault, Trans - Himalayan tectogen, Western Himalayan Syntaxes	≥ 5.0
2	75^oE - 78^oE	33^oN - 37^oN	Tibetan Plateau and Kashmir Ladakh Himalaya	Great Karakoram Range, Ladakh range, Zanskar range, Pir Panjal range **Rivers:** Chenab , Indus, Karkandor, Shyok	Altyn Tagh Fault Karakoram Fault, Main Boundary Thrust,	≥ 5.0
3	78^oE - 81^oE	33^oN - 37^oN	Trans Himalaya between Karakoram And Altyn Tagh fault	Kunlun Range ,Tibetan Plateau, Pangong Lake , Tarim Basin, **Rivers-** Chira, Indus, Karakashand, Shyok	Altyn Tagh fault , Karakoram fault, Trans-Himalayan tectonic	≥ 5.5
4	72^oE - 75^oE	29^oN - 33^oN	North Rajasthan and Punjab	Indo-Gangetic alluvial tracts **Rivers:** Chenab,Jhelum, Ravi, Sutlej	Delhi ridge, Kallar Kabar Fault, Jhelum fault, Punjab foredeep basin Sargodha Ridge, Lahore Ridge, Reasi Thrust, Salt Range Thrust, Bikaner basin	≥ 4.5

5	75°E - 78°E	29°N - 33°N	Himachal Himalaya and adjoining Indo-Gangetic Plains	Himalayan Orogenic Belt,Indo-Gangetic Plains, **Rivers:** Beas, Chandra, Ravi, Sutlej, Yamuna	Dehradun fault, Drang Thrust Jwalamukhi thrust Main Central Thrust, Vaikrita Thrust , Yamuna Tear	≥5.0
6	78°E - 81°E	29°N - 33°N	Himachal, Kumaon - Garhwal Himalaya & their Environ	Indo –Gangetic plains Tibetan Plateau, **Rivers:** Ganga, Kali, Ramganga, Sutlej, Yamuna	Karakoram Fault Main Himalayan belt Trans-Himalayan tectogen	≥ 5.5
9	75°E - 78°E	25°N - 29°N	North Delhi Fold belt and part of Vindhyan Basin	**Rivers:** Banas ,Chambal, Yamuna	Chittaurgarh Lineament , Machilpur Lineament Delhi fold belt, Great Boundary Fault,	≥ 5.5
10	78°E - 81°E	25°N - 29°N	Indo Gangetic plains of Uttar Pradesh and uplands of Madhya Pradesh	Alluvial tracts, foothill belt of Nepal Himalyas **Rivers:** Chambal ,Ganga, Sharda Yamuna	Great Boundary Fault, Lucknow Fault Moradabad Fault	≥ 4.5
11	81°E - 85°E	25°N - 29°N	Nepal Himalaya and Adjoining Indo-Gangetic Plains	Alluvial tracts of Uttar Pradesh Nepal Himalaya and its Tarai region **Rivers:** Ganga, Ghaghara and Yamuna	Mirganj Graben, Main Boundary Thrust, Main Central Thrust North Almora Thrust, South Almora Thrust,	≥ 4.0
12	85°E - 88°E	25°N - 29°N	Eastern Nepal Himalaya and Indo-Gangetic plains of Bihar	Indo-Gangetic plain **Rivers:** Ganga, Gandak, Ghaghara and Narayani	East Patna Fault, Everest lineamentJudi Fault, Gaurishankar lineament, Kung Co Graben Main Boundary Thrust, Main Central Thrust , MainFrontal Thrust, West Patna Fault	≥ 4.5

SEISMICITY

Seismicity refers to the geographic and historical distribution of earthquakes.Seismicity in Himalayas is much in evidence. Historical records reveal that devastating earthquakes have been a regular feature of the entire Himalayan system. Besides providing knowledge of what happened in the past thesehistorical records hold clues that might be of great significance for assessing risk potential associated with seismicity. Earthquakes cause tremendous loss to life and property all around the world every year. The amount of loss in terms of life, property and the disruption of key infrastructure and facilities has been rising continuously.

Seismicity data and frequency distribution of Earthquakes was studied as given in SEISAT sheet. This was a chronological listing of earthquakes data.Table 2.1 to Table 2.10 gives the Chronological listing of earthquakes of magnitudedata. Original data was for 1-14 columns, referring to Serial No, origin time, epicenter, Magnitude M_s, Magnitude M_b, Depth, sourceColumns were appended for EQ description, intensity, FPS, magnitude, and any other information, from other sources.

Table 2.1(a) to Table 2.9(a) gives the frequency distribution of earthquakes and Table 2.1(b) to Table 2.10(b) gives the frequency distribution of earthquakes on the basis of Table 2.1(a) to Table 2.9(a).

SEISAT 01 Western Himalayan Syntaxis between Kohistan Arc and Potwar Plateau

Table2.1 Chronological listing of earthquakes of magnitude ≥ 5.5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S.	Description	Y	M	D	H	m	s	Lat	long	M_s	M_b	Dept h Km	SOUR CE	Intensity	FPS	M?	More Info
1	Kashmir Earthquake	1885	05	30	-	-	-	34.12	74.61	-	-	-	BAN	MALLET I-III	-	7.0	Isoseismal map
2	-	1928	11	14	04	33	0.90	35.00	72.50	6.0	-	110	GR		-		
3	Himalayan Earthquake	1929	02	02										RF, VIII,VII		7.1	Isoseismal map
4	Hindukush Earthquake	1937	05	14										Milne VI-VII,VIII		7.2	Isoseismal map
5	-	1937	11	07	19	07	40.0	35.00	73.00	5.7	-	100	GR		-		
6	Pamir Earthquake	1939	11	21										MM, VI,VII,VIII		6.9	Isoseismal map
7	-	1940	01	26	15	20	45.0	36.50	72.00	5.7	-	200	GR		-		
8	-	1943	09	24	11	31	37.0	36.50	74.00	6.7	-	120	GR		-		
9	Badgam Earthquake	1963	09	02				33.9	74.7		5.1				available		
10	-	1965	01	29	20	06	02.4	35.60	73.60	-	5.7	33	CGS		available		
11	-	1972	09	03	16	48	28.8	35.98	73.42	6.2	6.3	36	ERL		available		
12	-	1972	09	03	16	48	29.5	35.94	73.32	-	6.2	45	ISC				
13	-	1972	09	03	23	03	53.6	35.95	73.24	-	5.6	46	ISC		available		
14	-	1972	09	04	00	14	10.0	35.92	73.37	-	5.5	55	ERL				
15	-	1972	09	04	13	42	20.7	35.90	73.34	-	5.7	57	ISC		available		
16	Pattan Earthquake	1974	12	28	12	11	46.6	35.05	72.91	-	5.9	45	ISC		available		
17		1977	02	14							5.2				available		
18		1981	09	12	07	15	53.8	35.68	73.60	6.0	6.1	30	ISC				
19		1990	03	05	20	47	06.6	36.90	73.02	6.1	5.7	60	ISC				
20		1990	03	05	20	51	23.0	36.78	73.05	-	5.5	91	ISC				

Frequency distribution of Earthquakes

The maximum clustering of seismic events is within the Kohistan Arc, considered to be part of the Indus-Kohistan Seismic Zone. This zone is seismically one of the most active domains of this sub-continent. Another moderate density cluster of seismic events is observed in northernmost tip of this area, north of the MKT. south of the MMT the seismic events are fairly well dispersed and no distinct clustering is observed.

Deep focus (>150 km) seismic events are comparatively more prevalent north of the MKT. within the kohistan Arc both intermediate (41-70 km) as well as shallow (0-40 km) foci events are common. However, south of MMT shallow focus events dominate over the intermediate focus events.

Table 2.1(a) Frequency distribution of Earthquakes

Mag Range	No of Events	%
≥7	Nil	-
≥6<7	5	1.6
≥5<6	59	18.9
≥4<5	166	53.4
<4	81	26.1
Total Event	311	

Table 2.1(b) Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥8		
≥7<8	3	15
≥6<7	6	30
≥5<6	11	55
≥4<5		
<4		
Total	15	

SEISAT 02 Tibetan Plateau and Kashmir Ladakh Himalaya

Table 2.2 Chronological listing of earthquakes of magnitude ≥ 5.0

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S NO	Description	Yr	Mo	Dt	Hr	Min	Sec	Lat	Long	Ms	Mb	Depth km	Source	Intensity	FPS	M	More Info
1	-	1917	05	17	21	45	50.0	34.20	77.50	6.0	-	-	IMD	-		-	-
2	-	1921	11	11	01	18	45.0	34.20	77.50	5.5	-	-	IMD	-		-	-
3	-	1923	09	30	23	10	15.0	35.50	77.00	5.5	-	-	IMD	-		-	-
4	-	1927	07	24	14	04	24.0	35.50	77.00	5.5	-	-	IMD	-		-	-
5	-	1927	09	24	-	-	-	36.50	75.00	5.5	-	-	IMD	-		-	-
6	-	1941	01	10	07	38	14.0	34.00	77.00	5.7	-	-	IMD	-		-	-
7	-	1947	07	10	10	19	27.0	33.00	77.00	6.0	-	60	GR	-		-	-
8	-	1950	08	19	22	42	56.0	36.50	75.50	5.5	-	-	IMD	-		-	-
9	-	1951	09	12	20	41	48.0	33.30	76.05	5.5	-	-	IMD	-		-	-
10	-	1962	06	17	04	39	39.0	33.30	76.20	5.5	-	20	IMD	-		-	-
11	-	1963	06	26	14	09	19.7	36.40	76.90	-	5.3	95	CGS	-	available	-	-
12	-	1965	06	22	05	49	27.7	36.20	77.60	-	5.7	107	CGS	-	available	-	-
13	-	1966	03	16	00	08	17.9	33.30	76.00	-	5.0	36	CGS	-		-	-
14	-	1967	02	20	15	18	39.0	33.63	75.33	-	5.5	20	ISC	-		-	-
15	-	1967	02	21	12	37	43.0	33.63	75.44	-	5.0	20	ISC	-	available	-	-
16	-	1967	02	24	00	17	39.7	33.63	75.35	-	5.0	39	CGS	-	available	-	-
17	-	1967	05	27	19	05	47.5	36.13	77.76	-	5.4	26	CGS	-		-	-
18	-	1970	09	09	07	48	48.0	35.30	77.60	-	5.1	35	IMD	-		-	-
19	-	1972	11	22	18	05	54.3	35.77	77.35	-	5.0	56	ISC	-		-	-
20	-	1973	01	16	21	31	25.9	33.29	77.83	-	5.1	39	ISC	-		-	-
21	-	1973	10	24	05	23	51.3	33.15	75.92	-	5.3	37	ISC	-	available	-	-
22	-	1973	10	24	19	57	17.9	33.06	75.73	-	5.0	52	ISC	-	available	-	-
23	-	1974	05	15	00	12	46.4	36.38	76.48	-	5.0	62	GS	-		-	-
24	-	1975	12	05	07	37	10.5	33.09	76.12	-	5.3	24	ISC	-		-	-
25	-	1975	12	11	10	09	50.2	33.00	76.17	-	5.0	42	IMD	-		-	-
26	-	1976	01	08	22	34	24.9	33.02	76.19	-	5.0	33	GS	-		-	-

27	-	1976	10	01	11	27	25.3	36.00	77.33	-	5.2	84	GS	-		-	-
28	-	1980	02	13	22	09	29.6	36.47	77.86	-	6.1	63	ISC	-		-	-
29	-	1980	05	01	05	43	12.7	33.02	75.92	-	5.0	35	GS	-		-	-
30	-	1980	08	11	07	33	20.9	35.68	77.58	-	5.0	77	GS	-		-	-
31	-	1980	10	08	06	57	02.3	35.13	77.10	-	5.1	33	GS	-		-	-
32	-	1982	07	09	08	01	15.0	36.33	76.79	-	5.2	06	ISC	-		-	-
33	-	1990	12	25	03	56	46.1	33.31	75.76	-	5.3	51	ISC	-		-	-
34	-	1993	04	08	03	49	33.2	35.69	77.64	-	5.0	24	ISC	-		-	-
35	-	1993	09	15	15	08	14.8	33.33	75.74	-	5.0	20	ISC	-		-	-

Frequency distribution of Earthquakes

Total 205 seismic events have been taken. Out of these, details of the earthquakes having magnitude ≥ 5 are given in table-1.Most prevalent earthquakes (48.39%) are in the magnitude range of ≥ 4 ≤ 5 (table-3). With respect to the spatial distribution of earthquake events, this area can broadly be subdivided into three zones.

The maximum concentration of the seismic events is in the southwestern corner between MCT and MBT where earthquakes are dominantly shallow focus (<40 km). This zone is the northwestern extension of the Kangra Seismic Block (Seisat-5). Towards north, the Indus-Shyok as well the Tethyan belt exhibit subdued seismicity. Further north within the Karakoram-Altyn Tagh Fault block fair concentration of seismic events is observed. In this part moderately deep focus (71-150 km) events are prevalent.

Table 2.2(a) Frequency distribution of Earthquakes

Mag Range	No of Events	%
≥7	Nil	-
≥6<7	3	1.5
≥5<6	31	15.1
≥4<5	99	48.3
<4	72	35.1
Total Event	205	

Table 2.2(b) Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥7		
≥6<7	3	91.42
≥5<6	32	8.57
≥4<5		
<4		
Total Event		35

SEISAT 03 Trans-Himalaya between Karakoram and Altyn Tagh Faults

Table 2.3 Chronological listing of earthquakes of magnitude ≥ 5.5,

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S NO	Description	Yr	Mo	Dt	Hr	Min	Sec	Lat	Long	Ms	Mb	Depth km	Source	Intensity	FPS	M	More Info
1	-	1926	08	06	22	45	54.0	35.50	78.50	6.2	-	-	GR	-		-	-
2	-	1937	11	15	21	37	34.0	35.00	78.00	6.5	-	100	GR	-		-	-
3	-	1966	10	20	00	53	39.8	33.60	78.60	-	5.0	33	CGS	-		-	-
4	-	1968	02	10	17	03	3.8	34.10	78.50	-	5.2	37	CGS	-		-	-
5	-	1968	02	11	20	38	27.0	34.15	78.70	-	5.1	24	ISC	-		-	-
6	-	1971	08	29	15	16	56.9	36.50	78.47	-	5.0	33	ERL	-		-	-
7	-	1974	08	03	04	08	13.8	35.45	80.64	-	5.0	20	GS	-		-	-
8	-	1975	04	28	11	06	43.7	35.80	79.85	-	5.8	33	ISC	-	Available	-	-
9	-	1975	04	28	11	58	34.6	35.95	79.96	-	5.2	31	ISC	-		-	-
10	-	1975	04	29	03	07	59.8	35.83	79.88	-	5.0	22	ISC	-		-	-
11	-	1975	04	30	03	06	27.0	35.96	80.15	-	5.1	29	GS	-		-	-
12	-	1975	05	05	19	27	44.3	35.89	79.98	-	5.0	22	ISC	-		-	-
13	-	1975	05	19	19	47	41.9	35.11	80.83	-	5.5	06	ISC	-	Available	-	-
14	-	1975	06	04	02	24	32.9	35.82	79.92	-	5.6	31	ISC	-	Available	-	-
15	-	1983	05	31	21	05	40.0	34.59	79.66	-	5.0	08	ISC	-		-	-
16	-	1984	03	14	15	32	32.5	34.23	79.63	-	5.1	22	ISC	-		-	-
17	-	1986	07	06	19	24	23.1	34.45	80.20	-	5.7	03	ISC	-	Available	-	-
18	-	1990	01	11	21	14	58.0	35.75	80.74	-	5.2	10	ISC	-		-	-
19	-	1992	04	05	07	47	48.0	35.77	80.68	-	5.5	13	ISC	-	Available	-	-
20	-	1998	06	14	07	30	18.9	35.60	78.42	-	5.0	41	ISC	-		-	-

Frequency distribution of Earthquakes

Out of a total of 152 seismic events which occurred between 1926 and 1996 in the area.20 events have magnitude ≥5 with the largest event that of 15 November, 1937(Table-1).The population of M ≥ 4 ≤ 5 eventis maximum and the majority of the events have focal depths of ≤ 40 km.

Table 2.3(a) Frequency distribution of Earthquakes

Mag Range	No of Events	%
≥7	Nil	0
≥6<7	3	1.1
≥5<6	18	11.8
≥4<5	111	73.0
<4	20	13.1
Total Event	152	

Table 2.3(b) Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥7		
≥6<7		
≥5<6	2	90
≥4<5	18	10
<4		
Total Event		
	20	

SEISAT04North Rajasthan and Punjab Sector

Table 2.4 Chronological listing of earthquakes of magnitude ≥ 4.5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S NO	Description	Yr	Mo	Dt	Hr	Min	Sec	Lat	Long	Ms	Mb	Depth km	Source	Intensity	FPS	M	More Info
1	-	1952	12	27	18	45	37.20	31.20	74.80	5.5	-	-	IMD	-	-	-	-
2	-	1963	09	09	21	41	43.6	31.30	72.10	-	4.7	33	CGS	-	-	-	-
3	-	1965	10	09	04	34	22.0	32.30	74.00	-	4.5	79	CGS	-	-	-	-
4	-	1970	10	14	00	36	34.5	31.23	74.34	-	5.2	33	NOS	-	-	-	-
5	-	1976	02	25	07	45	26.9	32.85	74.30	-	4.5	84	GS	-	-	-	-
6	-	1977	04	13	07	16	31.7	31.56	74.40	-	4.7	67	GS	-	-	-	-
7	-	1978	11	18	01	35	00.1	32.89	72.72	-	4.9	40	GS	-	-	-	-
8	-	1980	03	29	02	02	55.3	32.78	73.96	-	4.7	33	GS	-	-	-	-
9	-	1981	03	03	08	43	29.2	31.36	73.22	4.4	5.0	48	GS	-	-	-	-
10	-	1981	09	25	02	50	41.3	30.93	74.69	-	4.5	33	GS	-	-	-	-
11	-	1984	05	11	11	45	22.1	31.52	72.91	-	4.9	51	ISC	-	-	-	-
12	-	1984	10	06	10	03	59.0	30.34	73.62	-	4.5	10	ISC	-	-	-	-
13	-	1984	12	20	07	32	07.2	32.95	72.70	-	4.6	37	ISC	-	-	-	-
14	-	1984	12	27	20	22	06.0	32.91	72.67	-	4.6	22	ISC	-	-	-	-
15	-	1985	04	23	12	23	56.1	32.82	73.21	-	4.6	64	ISC	-	-	-	-
16	-	1985	05	22	13	57	50.9	31.31	73.34	-	5.1	0	ISC	-	-	-	-

Frequency distribution of Earthquakes

A total number of 67 earthquakes have been plotted in the sheet and earthquakes of magnitude ≥ 4.5 are listed in Table 1. Majority of the events have focal depths between 0 and 50 km and a few between 50 to 80 km. Seisamicity is mainly concentrated in two domains. One is in the Himalayan foothill region, particularly around Salt Range Thrust and Kallar Kabar Fault. The other is in and around the vicinity of Sargotha-Lahore-Delhi Range.

The parallelism of the Chenab, Ravi and Sultej river courses as well their drainage, following the saddles of the basement probably point towards the presence of NE-SW trending faults, traverse to the trend of the basement high.

Seismicity in this domain is possibly related to the basement faluts that border as well as traverse to this basement high. However, linearity in spatial distribution of seismicity points to their genetic relation more with the traverse faults.

Table 2.4(b) Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥8		
≥7<8		
≥6<7		
≥5<6	4	25
≥4<5	12	75
<4		
Total	16	

SEISAT 05Himachal Himalaya and adjoining Indogangetic plains

Table 2.5 Chronological listing of earthquakes of magnitude ≥ 5.0,

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S NO	Earthquake	Yr	Mo	Dt	Hr	Min	Sec	Lat	Long	Ms	Mb	Depth km	Source	**Intensity**	**FPS**	**M?**	**More Info**
1		1856	07	07	-	-	-	31.00	77.00	5.0		-	IMD				
2	Kangra Earthquake	1905	04	04	05	00	0.0	32.30	76.20	8.0		25	IMD	R.F. VIII,IX		8.0	Isoseismal map
3		1906	02	28	-	-	-	32.00	77.00	7.0		-	IMD				
4	Chamba Earthquake	1945	06	22	18	05	01.0	32.50	76.00	6.5		60	IMD	M.M. VII,VIII,IX		6.5	Isoseismal map
5		1947	07	10	10	19	20.0	32.60	75.90	6.2		-	IMD				
6		1950	08	12	03	59	06.0	32.60	75.90	5.5		-	IMD				
7		1962	09	15	12	35	08.0	31.90	76.20	5.5		-	IMD				
8		1965	05	31	02	04	42.9	32.65	77.99	-	5.1	28	ISC				
9		1973	04	01	09	45	27.2	32.12	77.83		5.6	90	ISC				
10		1975	10	30	14	36	42.5	32.90	75.99		5.2	34	GS				
11		1975	12	10	03	26	05.6	32.95	76.10		5.3	5	ISC				
12		1975	12	10	05	03	42.3	32.83	76.19		5.0	33	GS				
13		1975	12	11	10	09	50.2	32.99	76.17		5.0	42	ISC		available		
14		1976	01	07	00	24	52.9	32.97	76.12		5.3	40	ISC		available		
15		1976	02	05	12	04	30.6	31.23	77.03		5.0	6	ISC				
16		1977	12	21	02	08	10.0	32.84	76.63		5.1	33	GS				
17	Dharamshala Earthquake	1978	06	14	16	12	04.9	32.23	76.61		5.0	7	ISC	M.M. VII,VIII,IX	available	5.0	Isoseismal map
18	Kathua Earthquake	1980	08	23	21	36	49.9	32.96	75.75		5.2	3	ISC	M.M. V,VI,VII & VI,VII	available	5.2	Isoseismal map
19		1980	08	23	21	50	01.2	32.90	75.79		5.2	13	ISC		available		
20	Dharamshala Earthquake	1986	04	26	07	35	16.2	32.15	76.40		5.5	23	ISC	M.M.V,VI,VII	available	5.5	Isoseismal map
21	Chamba Earthquake	1995	03	24	-	-	-	-	-	-	-	-	-	MSK V,VI,VII		4.9	Isoseismal map

Frequency distribution of Earthquakes

A total of 99 seismic events of magnitude ≥ 4.0 have been taken. Out of these, 20 events are of magnitude ≥ 5 and are mostly confined to depths less than 40 km. events having magnitude $\geq 4 < 5$ are prevalent in this area (Table-3).

Seismicity activity is mainly concentrated along the Himalyan Belt particularly in the northwestern sector around Chamba. This sector with maximum clustering of seismic events represents part of the Kangra Seismic zone that continues towards north (Seisat 02). Out of the 20 events of magnitude ≥ 5, about 18 events define the zone.in this part of the Himalaya, 4 events having magnitude more than 6 are recorded. Out of these, 3 events (plot 2, 4 &5) lie on MBT, which include the famous Kangra Earthquake of 1905, while one event (plot No. 3) locates on the surface trace of Sundernagar Fault.

Table 2.5(a) Frequency distribution of Earthquakes

Mag Range	No of Events	%
≥8	1	1.0
≥7<8	1	1.0
≥6<7	2	2.0
≥5<6	16	16.2
≥4<5	49	49.5
<4	30	
Total Event	99	

Table 2.5(b)Frequency distribution of Earthquakes from Table 1

	No of Events	%
≥8		
≥7<8	1	5
≥6<7	3	15
≥5<6	16	80
≥4<5		
<4		
Total	20	

SEISAT 06 Himachal, Kumaon -Garhwal Himalaya & their Environ

Table 2.6 Chronological listing of earthquakes of magnitude ≥ 5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S NO	**Description**	Yr	Mo	Dt	Hr	Min	Sec	Lat	Long	Ms	Mb	Depth km	Source	**Intensity**	**FPS**	**M?**	**More Info**
1		1816	05	26	22	-	-	30.90	79.00	6.5	-	-	IMD				
2		1842	03	05	21	10	-	30.00	78.00	5.5	-	-	IMD				
3		1902	06	16	-	-	-	31.00	79.00	6.0	-	-	IMD				
4	Kangra Earthquake	1905	04	04	-	-	-	-	-	-	-	-	-	R.F. VI,VII		8.0	ISOSEISMAL
5		1906	06	13	-	-	-	31.00	79.00	6.0	-	-	IMD				
6		1911	10	14	23	24	00.0	31.00	80.50	6.7	-	-	GR				
7		1916	08	28	-	-	-	30.00	81.00	7.5	-	-	IMD				
8		1926	07	27	07	23	36.0	30.50	80.05	6.0	-	-	IMD				
9		1927	10	08	10	34	28.0	30.50	80.50	6.0	-	-	IMD				
10		1935	03	05	22	15	53.0	29.75	80.25	5.8	-	-	GR				
11		1937	10	20	03	00	00.0	31.10	78.01	5.5	-	-	IMD				
12		1945	06	04	12	08	55.0	30.30	80.00	6.5	-	60	IMD				
13		1947	08	19	20	07	06.0	31.20	79.09	5.9	-	-	IMD				
14		1949	02	05	08	55	20.0	31.20	79.05	5.5	-	-	IMD				
15		1955	06	27	10	14	09.0	32.00	78.50	5.7	-	-	IMD				
16		1958	12	28	05	34	36.0	29.50	80.00	6.0	-	-	CGS		Available		
17		1959	05	12	00	35	47.0	32.40	78.66	6.3	-	-	ISS				
18		1961	12	24	07	13	30.0	29.43	80.83	5.6	-	59	IMD				
19		1962	07	13	05	01	08.6	30.50	79.60	5.5	-	25	IMD				
20		1962	07	14	15	58	53.7	30.40	79.50	5.5	-	40	IMD				
21		1963	01	30	10	33	50.0	29.50	80.90	5.5	-	-	IMD				
22		1964	09	26	00	46	02.6	29.96	80.46	-	5.8	50	ISC		Available		
23		1966	03	06	02	15	57.2	31.50	80.50	-	6.0	50	ISC		Available		
24		1966	06	27	10	41	08.1	29.71	80.83	-	6.0	06	ISC				
25		1966	06	27	10	59	18.1	29.62	80.89	-	6.0	36	ISC		Available		
26		1966	12	16	20	52	16.3	32.38	80.79	-	5.7	19	ISC		Available		
27		1975	01	19	08	01	57.7	31.93	78.49	-	6.2	01	ISC				
28	Kinnaur Earthquake	1975	01	19	08	12	09.8	32.57	78.52	-	5.8	49	ISC	M.M.VII,VIII,IX	Available	7.0	ISOSEISMAL
29		1975	07	29	02	40	51.2	29.93	78.49	-	5.5	-	ISC		Available		
30		1979	05	20	22	59	11.6	31.05	80.27	-	5.7	16	ISC		Available		
31		1986	07	16	22	03	07.0	31.05	78.00	-	5.6	13	ISC		Available		
32	Uttarkashi Earthquake	1991	10	19	21	23	15.0	30.77	78.79	-	6.4	15	ISC	MSK VI,VII,VIII	Available	6.4	ISOSEISMAL
33	Chamoli Earthquake	1996	01	23	-	-	-	-	-	-	-	-	-	MSK IV,V		4.5	ISOSEISMAL
34	Garhwal Earthquake	1996	03	26	-	-	-	-	-	-	-	-	-	MSK IV,V,VI		5.0	ISOSEISMAL
35	Indo-Nepal Earthquake	1997	01	05	08	47	25.0	29.80	80.50	-	5.5	16	IMD/GSI	MSK V,VI		5.5	ISOSEISMAL

Frequency distribution of Earthquakes

Seismically this area constitutes one of the most active domains of the Himalaya. Within a period of 181 years from 1816 to 1997, a total of 297 seismic events have been taken. Out of these 32 events are of $M \geq 5.5$ (Table-1). Area wise, seismicity is quite high in the Main Himalayan belt. Subdued within the Tibetan Plateau and a few events locate over the Indo-Gangetic plains. Within the Himalyan belt clustering of seismic events define two distinct zones, having different trends.

The Kinnaur seismic zone, located in the northwestern corner, has a N-S alignment and a traversed by a number of half-graben faults defining the Kaurik Fault System. The other zone, extending from Uttarkashi (in the west) to Dharchula (in the east), is sub parallel to Himalayan trend and lies in close proximity to MCT. Both these zones are dominated by shallow focus (0-40 km) events, through some deeper events are also recorded mainly from the Kaurik Fault Zone.

Table 2.6(a) Frequency distribution of Earthquakes

Mag Range	No of Events	%
≥8	NIL	-
≥7<8	1	0.3
≥6<7	12	4.0
≥5<6	63	21.2
≥4<5	149	50.2
<4	73	24.6
Total Event	297	

Table 2.6(b)Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥8		
≥7<8	2	5.71
≥6<7	14	40
≥5<6	19	54.28
≥4<5		
<4		
Total	35	

SEISAT 09 North Delhi Fold belt and part of Vindhyan Basin

Table 2.7 Chronological listing of earthquakes of magnitude

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
S.	**Description**	**Y**	**M**	**D**	**H**	**m**	**s**	**Lat**	**long**	**M_s**	**M_b**	**Depth Km**	**SOURCE**	**Intensity**	**FPS**	**M?**	**More Info**	**I_{max}**
1	-	1720	07	15	-	-	-	28.70	77.20				OLD	-	-	-	-	X
2	-	1803	09	01	-	-	-	27.50	77.70				OLD	-	-	-	-	IX
3	-	1825	03	22	-	-	-	28.70	77.20				OLD	-	-	-	-	V
4	-	1830	07	17	-	-	-	28.70	77.20				OLD	-	-	-	-	V
5	-	1831	10	24	-	-	-	28.70	77.20				OLD	-	-	-	-	VII
6	-	1833	09	20	-	-	-	29.00	77.20				OLD	-	-	-	-	V
7	-	1842	01	02	-	-	-	28.70	77.20				OLD	-	-	-	-	IV
8	-	1842	07	04	-	-	-	28.70	77.20				OLD	-	-	-	-	VI
9	-	1842	09	27	-	-	-	28.70	77.20				OLD	-	-	-	-	IV
10	-	1842	11	06	-	-	-	28.70	77.20				OLD	-	-	-	-	IX
11	-	1930	06	25	-	-	-	25.50	77.50	5.6			ANT	-	-	-	-	-
12	-	1956	10	10	-	-	-	28.20	77.70	6.2			ANT	-	-	-	-	-
13	Delhi earthquake	1960	08	27	-	-	-	28.20	77.40	6.0			SRS	-	-	-	-	-
14	-	1970	03	18	07	40	55.0	28.95	76.60		4.7	18	ISC	-	-	-	-	-
15	-	1973	06	26	-	-	-	27.00	75.20		4.0	0	IMD	-	-	-	-	-
16	-	1974	01	02	17	35	14.0	27.98	75.13			33	ISC	-	-	-	-	-
17	-	1974	03	26	17	46	00.0	27.87	75.52			33	ISC	-	-	-	-	-
18	-	1980	04	27	17	00	33.3	28.61	77.64		4.7	33	GS	-	-	-	-	-
19	-	1981	05	11	15	33	48.0	28.30	76.50			33	ISC	-	-	-	-	-
20	-	1986	11	02	06	16	42.3	26.54	77.30			10	ISC	-	-	-	-	-
21	-	1988	09	20	06	56	06.0	28.87	76.92			9	ISC	-	-	-	-	-
22	-	1990	01	01	10	27	56.1	27.85	75.30			33	ISC	-	-	-	-	-
23	-	1990	08	27	16	38	00.0	28.96	76.58		4.0	33	ISC	-	-	-	-	-
24	-	1991	04	27	07	44	30.2	28.20	76.01			33	ISC	-	-	-	-	-
25	-	1993	12	03	09	48	47.6	28.90	76.72		3.9	40	ISC	-	-	-	-	-

Frequency distribution of Earthquakes

Twenty five earthquake are plotted (Table 1) in the map. These events are mostly shallow and lie within the alluvial covered northern part, in coinearity with the highly faulted domain between Bharatpur- Mt Abu Lineament and Mehendragarh Fault. Only one low magnitude earthquake lies in the vicinity of the Great Boundary Fault. Earthquake from historic and pre-instrumental period lie in close proximity to the Yamuna River course between Delhi and Mathura.

Table 2.7(b)Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥8		
≥7<8		
≥6<7	1	4
≥5<6	2	2
≥4<5	5	20
<4		
Total	25	

SEISAT 10 Indo Gangetic plains of Uttar Pradesh and uplands of Madhya Pradesh

Table 2.8 Chronological listing of earthquakes data

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S.	**Description**	**Y**	**M**	**D**	**H**	**m**	**s**	**Lat**	**long**	**M_s**	**M_b**	**Depth Km**	**SOURCE**	**Intensity**	**FPS**	**M?**	**More Info**
1	-	1956	12	10	15	31	34.0	28.5	78.00	6.0	-	-	CGS	-	-	-	-
2	-	1966	08	15	02	15	28.0	28.67	78.93	5.6	-	5	ISC	-	available	-	-
3	-	1983	12	24	04	55	12.0	28.23	79.61	-	-	33	ISC	-	-	-	-
4	-	1992	01	05	16	58	49.0	25.60	79.50	-	-	100	ISC	-	-	-	-
5	Bhind Earthquake	1994	08	31	23	30	00	25.30	78.40	4.8	-	8	IMD	-	-	-	-

Table 2.8(b)Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥8		
≥7<8		
≥6<7		
≥5<6	1	20
≥4<5	1	20
<4		
Total	5	

SEISAT 11 Nepal Himalaya and Adjoining Indo-Gangetic Plains

Table 2.9 Chronological listing of earthquake data> 4.0

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S NO	Description	Yr	Mo	Dt	Hr	Min	Sec	Lat	Long	Ms	Mb	Depth km	Source	Intensity	FPS	M	More Info
1	-	1925	11	06	19	20	45.0	26.50	81.50	-			ISS	-	-	-	-
2	-	1936	05	27	06	19	19.0	28.50	83.50	7.0	6.9		ABE	-	-	-	-
3	-	1952	11	08	07	06	00.0	28.50	83.20	-			ISS	-	-	-	-
4	-	1953	08	29	01	58	25.0	27.90	82.20	-			ISS	-	-	-	-
5	-	1954	09	04	06	43	45.0	28.30	83.80	6.5	6.0		ISS	-	-	-	-
6	-	1954	11	20	19	06	18.0	27.50	82.50				SHL	-	-	-	-
7	-	1958	04	30	09	33	35.0	28.50	82.00				SHL	-	-	-	-
8	-	1959	10	28	00	00	42.0	28.50	82.50				BCI	-	-	-	-
9	-	1961	07	11	17	23	42.3	27.10	81.00			25	CGS	-	-	-	-
10	-	1965	06	01	07	52	25.1	28.59	83.06		5.3	20	ISC	-	available	-	-
11	-	1966	11	05	18	53	03.3	28.22	83.87		4.8	33	ISC	-	available	-	-
12	-	1973	10	16	09	50	43.7	28.36	82.99		5.0	34	ISC	-	-	-	-
13	-	1982	05	29	20	29	46.4	28.53	83.58		4.4	33	ISC	-	-	-	-
14	-	1982	09	09	12	05	34.0	28.80	81.36	4.2	4.4	33	ISC	-	-	-	-
15	-	1982	09	09	12	28	58.9	28.68	81.99		4.5	33	ISC	-	-	-	-
16	-	1983	02	20	10	08	39.0	28.90	81.42		-	33	ISC	-	-	-	-
17	-	1984	05	30	22	27	25.0	28.99	83.98		4.5	24	ISC	-	-	-	-
18	-	1984	07	21	20	02	41.0	28.80	82.10		4.3	37	ISC	-	-	-	-
19	-	1984	11	18	22	04	35.5	28.67	83.32		5.4	0	ISC	-	-	-	-
20	-	1984	12	05	14	14	14.0	27.22	81.67	5.1	4.7	21	ISC	-	-	-	-
21	-	1985	05	06	20	59	45.5	28.43	82.37		4.7	42	ISC	-	-	-	-
22	-	1986	10	21	08	57	08.0	28.86	83.96	4.2	4.5	30	ISC	-	-	-	-
23	-	1987	12	22	14	12	41.0	28.90	83.02		4.2	10	ISC	-	-	-	-
24	-	1987	01	19	07	46	23.8	28.20	83.60	4.7	5.2	24	ISC	-	-	-	-
25	-	1988	01	19	08	12	06.6	28.21	83.53	4.2	4.9	41	ISC	-	-	-	-
26	-	1988	01	10	07	36	58.0	25.20	83.80			33	ISC	-	-	-	-
27	-	1989	06	12	10	15	46.7	28.70	82.42	4.5	4.8	21	ISC	-	-	-	-
28	-	1989	03	01	22	52	49.2	28.31	83.78		4.3	33	ISC	-	-	-	-

29	-	1990	I0	21	20	20	02.0	28.10	82.40			33	ISC	-	-	-	-
30	-	1990	02	21	07	21	14.3	27.59	82.43		4.7	33	ISC	-	-	-	-
31	-	1990	05	20	09	10	02.6	28.45	83.22		4.8	33	ISC	-	-	-	-
32	-	1990	05	20	09	12	26.1	28.30	83.20		4.6	33	ISC	-	-	-	-
33	-	1990	05	20	18	01	54.4	28.37	83.17		4.4	33	ISC	-	-	-	-
34	-	1990	11	19	16	42	19.0	27.70	81.00			33	ISC	-	-	-	-
35	-	1991	12	20	17	04	43.3	28.16	82.88		4.9	61	ISC	-	-	-	-
36	-	1992	06	01	02	49	24.6	28.79	81.67	3.8	4.3	33	ISC	-	-	-	-
37	-	1992	01	11	13	03	25.0	28.40	81.02		3.7	33	ISC	-	-	-	-
38	-	1992	06	02	22	07	45.3	28.94	81.90	4.7	5.2	56	ISC	-	-	-	-
39	-	1993	06	13	15	40	05.5	28.95	82.84	4.9	4.6	33	ISC	-	-	-	-
40	-	1993	04	12	00	57	58.0	28.41	82.79		4.3	33	ISC	-	-	-	-
41	-	1993	I0	20	07	23	38.9	28.73	82.22	4.6	4.9	37	ISC	-	-	-	-
42	-	1993	10	20	16	15	59.4	28.69	82.25	4.5	5.1	35	ISC	-	-	-	-
43	-	1993	11	22	00	27	07.0	28.26	82.79		4.6	33	ISC	-	-	-	-

Frequency distribution of Earthquakes

The earthquake catalogue indicates occurrence of 43 seismic events between the period 1925 and 1993 within this sheet. Of these, the largest event of Ms 7.0 was of 27th May, 1936 (Table-1) Majority of the events (82%) are confined to the Himalayan belt, while a few lie in the Indo-Gangetic plains. Maximum events (53.5%) come under the magnitude class 24<5 (Table-3) and are shallow focus (0-40 km) type

Table 2.9(a) Frequency distribution of Earthquakes

Mag Range	No of Events	%
≥7	nil	
≥6<7	2	4.7
≥5<6	6	13.9
,≥4<5	23	53.5
<4	12	27.9
Total Event	43	

Table 2.9(b)Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥7	1	2.3
≥6<7	1	2.3
≥5<6	4	9.3
≥4<5	26	60.46
<4		
Total Event	43	

SEISAT 12 Eastern Nepal Himalaya and Indo-Gangetic plains of Bihar

Table 2.10 Chronological listing of earthquakes of magnitude ≥ 4.5,

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S.	**Description**	**Y**	**M**	**D**	**H**	**m**	**s**	**Lat**	**long**	**M_s**	**M_b**	**Depth Km**	**SOURCE**	**Intensity**	**FPS**	**M?**	**More Info**
	Bihar Nepal Earthquake	**1833**	**08**	**20**	-	-	-	-						**IV-IX**			Isoseismal
1	Bihar Nepal Earthquake	1934	01	15	08	43	18.0	26.50	86.50	8.3	7.8		ABE	X-IV	-	-	Isoseismal
2	-	1964	01	25	07	13	30.8	28.27	86.64	-	4.5	66	ISC	-	-	-	-
3	-	1966	01	11	12	42	06.2	27.30	85.80	-	4.5	33	ISC	-	-	-	-
4	-	1967	03	02	11	47	12.7	28.70	86.38	-	4.8	20	ISC	-	-	-	-
5	-	1968	10	28	17	48	29.1	27.57	86.03	-	4.9	37	ISC	-	-	-	-
6	-	1969	02	13	03	21	30.0	27.90	85.40	-	5.0	-	ISC	-	-	-	-
7	-	1970	02	26	19	30	14.5	27.62	85.70	-	5.0	96	ISC	-	available	-	-
8	-	1970	07	21	15	37	44.7	27.94	84.81	-	4.8	40	ISC	-	-	-	-
9	-	1971	06	06	10	34	49.0	28.04	85.58	-	4.9	42	ISC	-	-	-	-
10	-	1974	03	24	16	17	39.6	27.63	86.01	-	4.7	3	ISC	-	-	-	-
11	-	1974	03	24	16	17	39.6	27.66	86.00	5.7	5.4	20	ISC	-	available	-	-
12	-	1974	09	27	05	26	33.6	28.59	85.51	-	5.5	20	ISC	-	available	-	-
13	-	1975	01	31	12	38	50.8	28.09	84.77	-	5.0	19	ISC	-	available	-	-
14	-	1975	11	21	13	49	28.0	27.00	86.50	-	4.9	-	ISC	-	-	-	-
15	-	1976	09	12	15	36	11.8	27.68	85.94	-	4.5	33	ISC	-	-	-	-
16	-	1978	02	10	17	29	47.1	28.03	84.69	4.7	5.3	-	ISC	-	available	-	-
17	-	1978	08	13	22	28	04.6	28.07	85.24	-	4.5	1	ISC	-	-	-	-
18	-	1978	10	04	13	53	50.7	27.82	85.93	4.5	5.2	19	ISC	-	-	-	-
19	-	1978	12	25	20	00	02.7	28.07	84.07	-	4.6	33	ISC	-	-	-	-
20	-	1981	04	09	17	19	29.0	28.09	84.67	-	4.5	17	ISC	-	-	-	-
21	-	1982	02	20	13	21	49.3	27.71	85.73	-	4.5	33	ISC	-	-	-	-
22	-	1982	08	03	08	03	31.5	28.03	85.57	-	4.7	33	ISC	-	-	-	-
23	-	1983	08	23	22	43	12.8	27.95	84.94	-	4.5	64	ISC	-	-	-	-
24	-	1984	01	06	23	48	11.0	27.83	84.61	-	4.5	49	ISC	-	-	-	-
25	-	1984	01	25	23	49	45.0	27.49	86.10	-	4.6	12	ISC	-	-	-	-
26	-	1986	01	06	09	50	42.0	27.85	85.32	-	4.8	34	ISC	-	-	-	-
27	-	1986	01	10	03	46	30.9	28.65	86.56	-	5.5	53	ISC	-	available	-	-
28	-	1986	02	02	00	13	50.7	27.92	86.45	-	4.5	33	ISC	-	- -	-	-

29	-	1986	04	12	12	44	02.2	28.63	86.57	-	4.8	33	ISC	-	-	-	-
30	-	1987	04 .	30	18	30	29.0	28.40	85.80	-	4.5	33	ISC	-	-	-	-
31	-	1987	11	25	19	20	40.0	27.70	86.17	-	4.5	33	ISC	-	-	-	-
32	-	1988	04	11	12	11	31.2	27.57	85.86	-	4.7	38	ISC	-	-	-	-
33	-	1988	04	20	06	40	25.8	27.02	86.72	4.9	5.4	25	ISC	-	available	-	-
34	-	1988	04	25	16	04	03.7	26.90	86.54	-	4.7	79	ISC	-	-	-	-
35	Bihar Nepal Earthquake	1988	08	20	23	09	10.1	26.72	86.63	6.6	6.4	65	ISC	IX-IV	available		Isoseismal
36	-	1988	08	24	09	55	34.3	26.77	86.44	4.4	4.7	41	ISC	-	-	-	-
37	-	1988	09	01	22	04	11.3	26.80	86.53	-	4.5	33	ISC	-	-	-	-
38	-	1988	09	21	13	51	13.6	26.63	85.61	-	4.5	46	ISC	-	-	-	-
39	-	1988	10	29	09	10	52.7	27.87	85.64	5.0	5.5	15	ISC	-	available	-	-
40	-	1989	02	13	05	44	43.0	27.30	86.00	-	4.5	-	NEIC	-	-	-	-
41	-	1990	07	13	11	50	11.0	28.20	86.90	-	4.5	33	ISC	-	-	-	-
42	-	1992	04	01	13	41	02.0	27.34	86.97	-	4.6	22	ISC	-	-	-	-
43	-	1992	08	09	22	34	46.0	28.71	86.54	-	4.7	34	ISC	-	-	-	-
44	-	1993	07	03	02	00	22.4	28.55	86.86	4.2	4.6	33	ISC	-	-	-	-
45	-	1993	07	05	22	11	09.6	27.90	85.06	4.4	4.7	33	ISC	-	-	-	-
46	-		12	14	02	27	46.7	28.36	86.71	-	4.7	56	ISC	-	-	-	-

Frequency distribution of Earthquakes

A total of 91 earthquake events have been plotted in this sheet, which are commonly shallow focus (< 70km) type. Out of these, events having magnitude 24.5 are presented in Table-I.

Most of these events are confined to the Himalayan belt, particularly in the area between MBT and MCT. In the northern Tethyan belt the earthquake occurrence is comparatively less, except in the northeastern corner in the vicinity of Kung Co Graben where a moderate clustering of events is observed. Compared to these two belts the frequency of occurrence of earthquakes in the foredeep plain is subdued except east of Madhubani where a clustering of events is observed in close spatial association with EPF in the vicinity of the Himalayan foothill belt.

The most devastating earthquakes of 1934 and 1988 had epicenters within this cluster. Such locales where transverse basement faults meet other faults of the Himalayan deformation front are considered to be seismically vulnerable because of concentration of stress along the transverse structures within such domains.

Table 2.10(b)Frequency distribution of Earthquakes from Table 1

Mag Range	No of Events	%
≥7	1	2.17
≥6<7		
≥5<6	1	2.17
≥4<5	7	15.22
<4	37	80.43
Total Event	46	

SEISMICITY CONTINUED

An isoseismal (line) is a contour or line on a map bounding points of equal intensity for a particular earthquake.Isoseismal maps are maps that show the distribution of intensities from the shaking of an earthquake with contours of equal intensity.

This chapter deals with isoseismal maps and fault plane solutions of earthquakes which are within the study area, as given in SEISAT sheets. A list of isoseismal maps considered is given in Table 3.1, for 18 earthquakes, for the years 1833 to 1998.

Table 3.1 List of Isoseismals considered

SN	Name of Earthquake	Date	Magnitude	Intenty scale	Details of Isoseismals	SEIS AT	Fig no
1.	Nepal Earthquake	1833/08/20	-	-	IX,VIII,VII,VI,V,IV	12	3.1.
2.	Kashmir Earthquake	1885/05/30	7.0	Mallet	I,II,III	01	3.2.
3.	Kangra Earthquake	190504/04	8.0	R.F.	VIII,IX	05	3.3.
4.	Kangra Earthquake	1905/04/04	8.0	R.F.	VI,VII	06	3.4.
5.	Himalayan Earthquake	1929/02/02	7.1	R.F.	VII,VIII	01	3.5.
6.	Hindukush Earthquake	1937/05/14	7.2	Milne	VI-VII,VIII	01	3.6.
7.	Pamir Earthquake	1939/11/22	6.9	M.M.	VI,VII,VIII	01	3.7.
8.	Chamba Earthquake	1945/06/22	6.5	M.M.	VII,VIII,IX	05	3.8.
9.	Kinnaur Earthquake	1975/01/19	7.0	M.M.	VII,VIII,IX	06	3.9.
10.	Dharamshala Earthquake	1978/06/14	5.0	M.M.	V,VI	05	3.10
11.	Kathua Earthquake	1986/04/23	5.2	M.M.	V,VI,VII & VI,VII	05	3.11
12.	Dharamshala Earthquake	1986/04/26	5.5	M.M.	V,VI,VII	05	3.12
13.	Bihar Nepal Earthquake	1988/08/20	-	-	IX,VIII,VII,VI,V,IV	12	3.13
14.	Uttarkashi Earthquake	1991/10/20	6.4	M.S.K.	VI,VII,VIII	06	3.14
15.	Chamba Earthquake	1995/03/2	4.9	M.S.K.	V,VI,VII	05	3.15
16.	Chamoli Earthquake	1996/01/23	4.5	M.S.K.	IV,V	06	3.16
17.	Garhwal Earthquake	1996/03/26	5.0	M.S.K.	IV,V,VI	06	3.17
18.	Indo-Nepal Earthquake	1997/01/05	5.5	M.S.K.	V,VI	06	3.18

Isoseismal map of Bihar Nepal earthquake (20/08/1833)

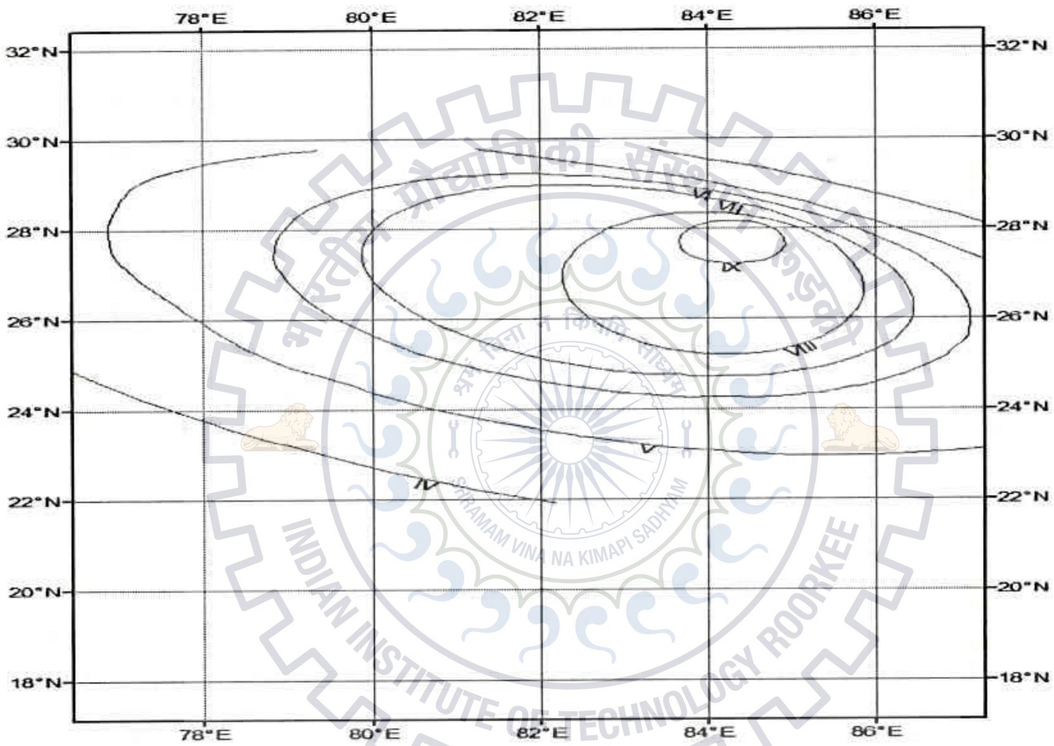


Fig 3.1Isoseismal map of Bihar Nepal earthquake of 20th Aug, 1833

S.	Description	Y	M	D	H	m	s	Lat	long	M_s	M_b	Depth Km	SOURCE	Intensity	FPS	M?	More Info
	Bihar Nepal Earthquake	1833	08	20	-	-	-	-						IV-IX			Isoseismal

Isoseismals of Kashmir Earthquake (30/05/1885)

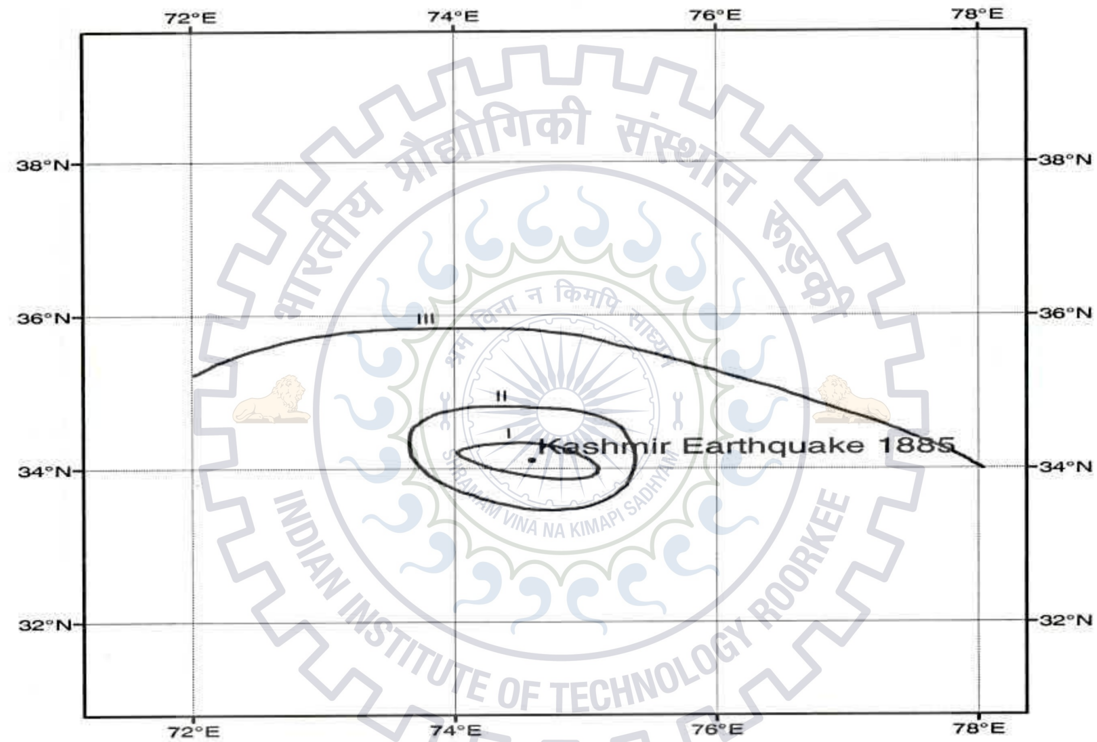


Fig 3.2 Isoseismal map of Kashmir Earthquake of (30/05/1885)

S.	Description	Y	M	D	H	m	s	Lat	long	M_s	M_b	Dept h Km	SOUR CE	Intensity	FPS	M?	More Info
1	Kashmir Earthquake	1885	05	30	-	-	-	34.12	74.61	-	-	-	BAN	MALLET I-III	-	7.0	Isoseismal map

Isoseismals of KangraEarthquake (04/04/1905)

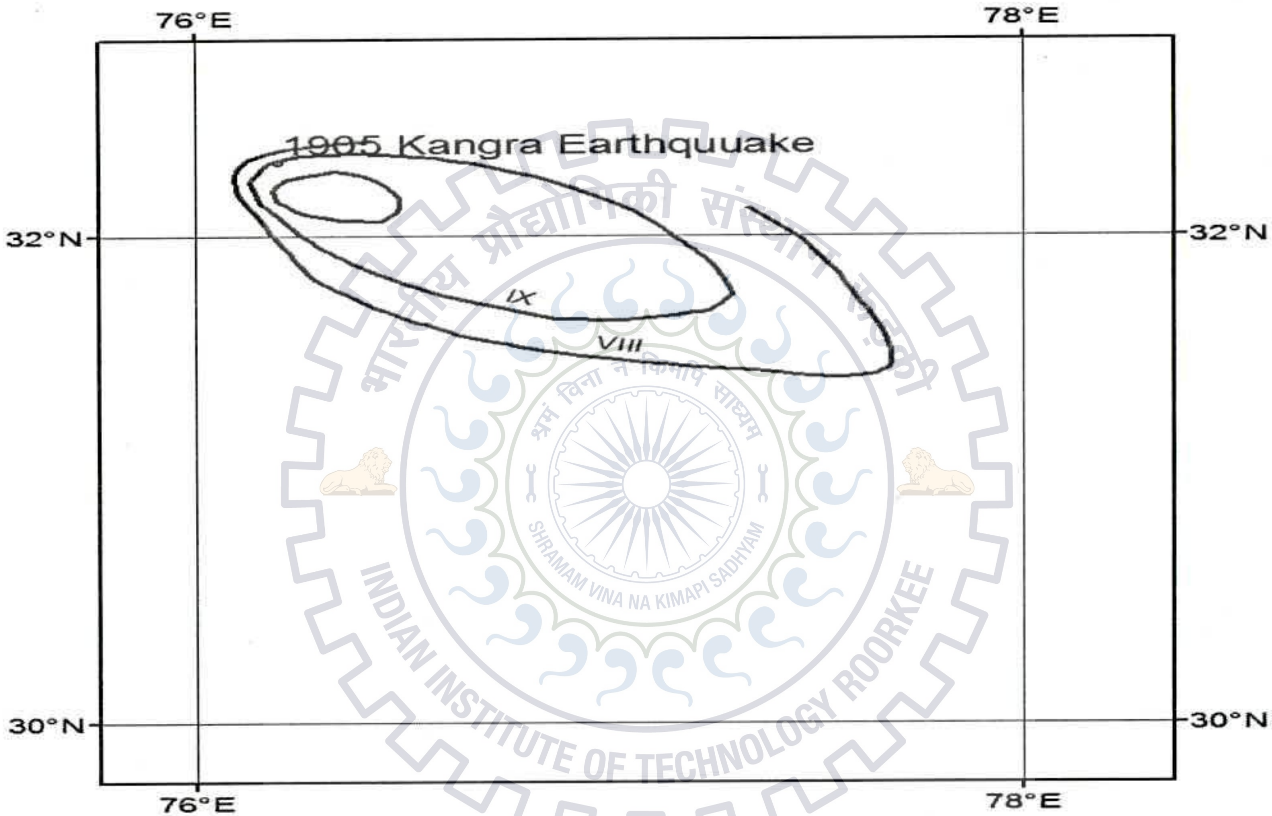


Fig 3.3 Isoseismal map of KangraEarthquake(04/04/1905)

S.	Description	Y	M	D	H	m	s	Lat	long	M_s	M_b	Depth Km	SOURCE	Intensity	FPS	M?	More Info
1	Kangra Earthquake	1905	04	04	05	00	0.0	32.30	76.20	8.0		25	IMD	R.F. VIII,IX		8.0	Isoseismal map

Isoseismals of Kangra Earthquake (04/04/1905)

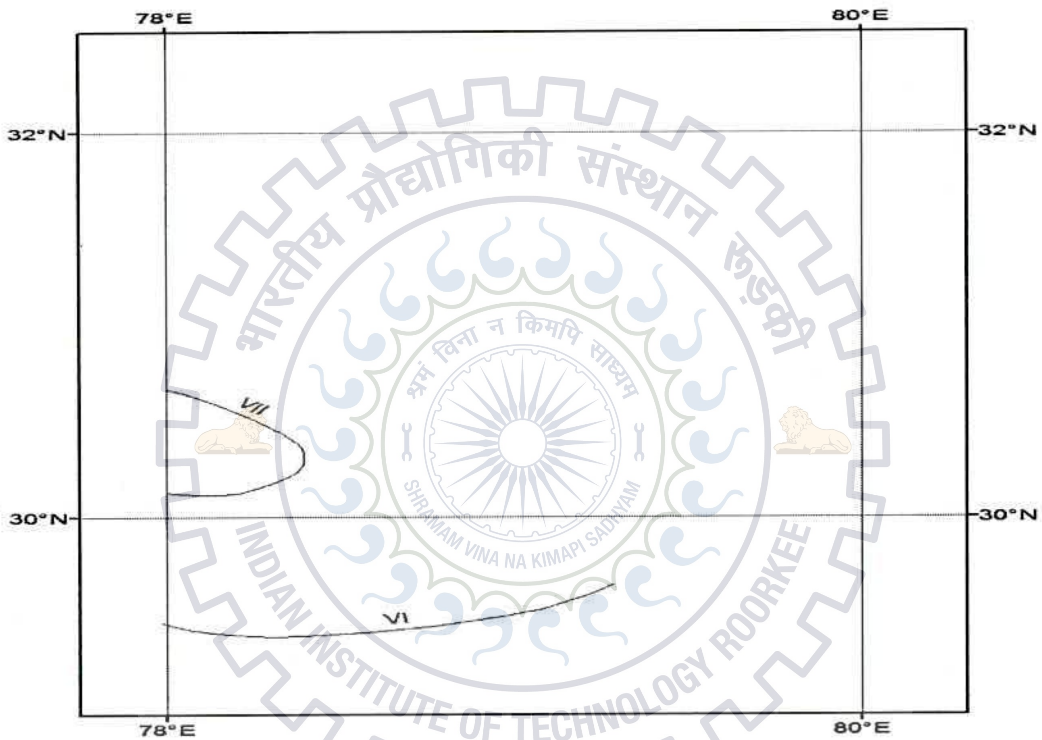


Fig 3.4Isoseismal map of Kangra Earthquake(1905/04/04)

S.	Description	Y	M	D	H	m	s	Lat	long	M_s	M_b	Depth Km	SOURCE	Intensity	FPS	M?	More Info
1	Kangra Earthquake	1905	04	04	-	-	-	-	-	-	-	-	-	R.F. VI,VII		8.0	ISOSEISMAL

Isoseismal of Himalayn Earthquake(02/02/1929)

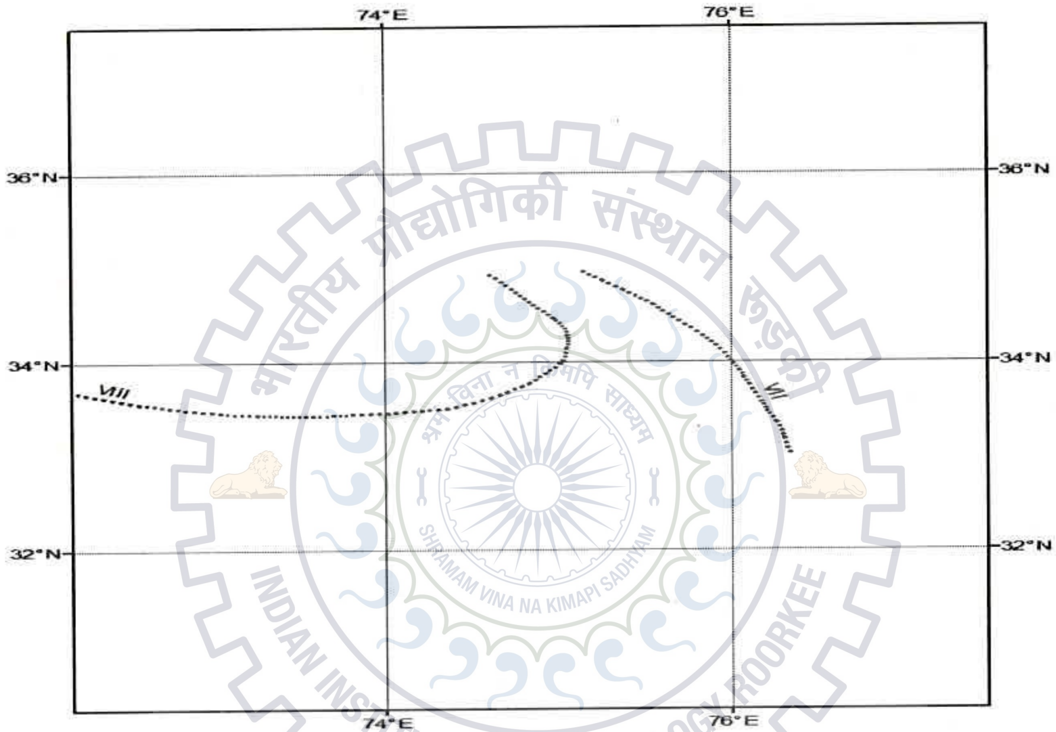


Fig 3.5Isoseismals map of Himalayn Earthquake(2nd Feb,1929)

S.	Description	Y	M	D	H	m	s	Lat	long	M_s	M_b	Dept h Km	SOURCE	Intensity	FPS	M?	More Info
1	Himalayan Earthquake	1929	02	02										RF, VIII,VII		7.1	Isoseismal map

Composite Isoseismal map of Northwest Himalayn Earthquake

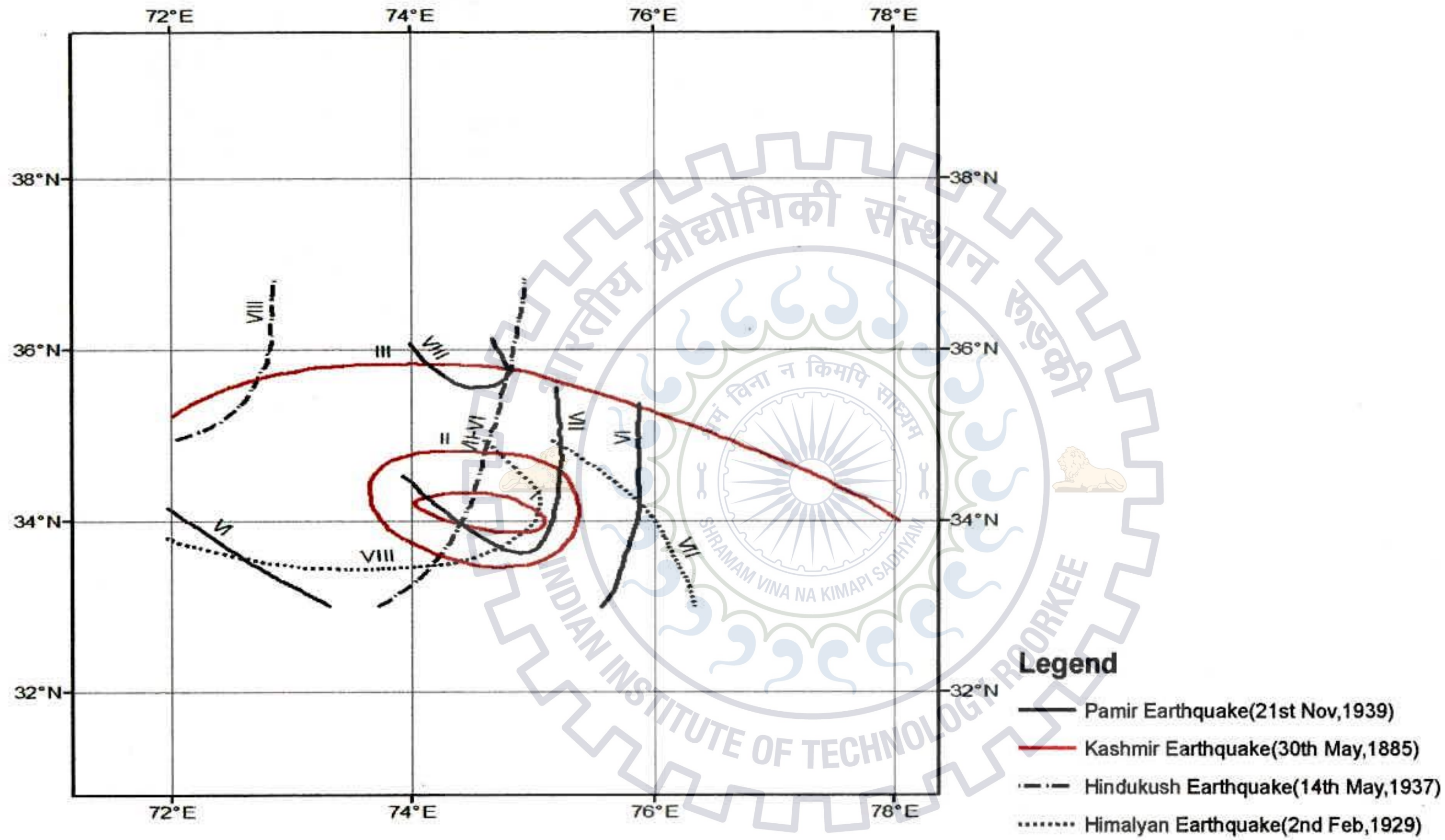


Fig 3.19 CompositeIsoseismals map of Northwest Himalayn Earthquake

Composite Isoseismal map of Earthquakes of Himachal Himalaya

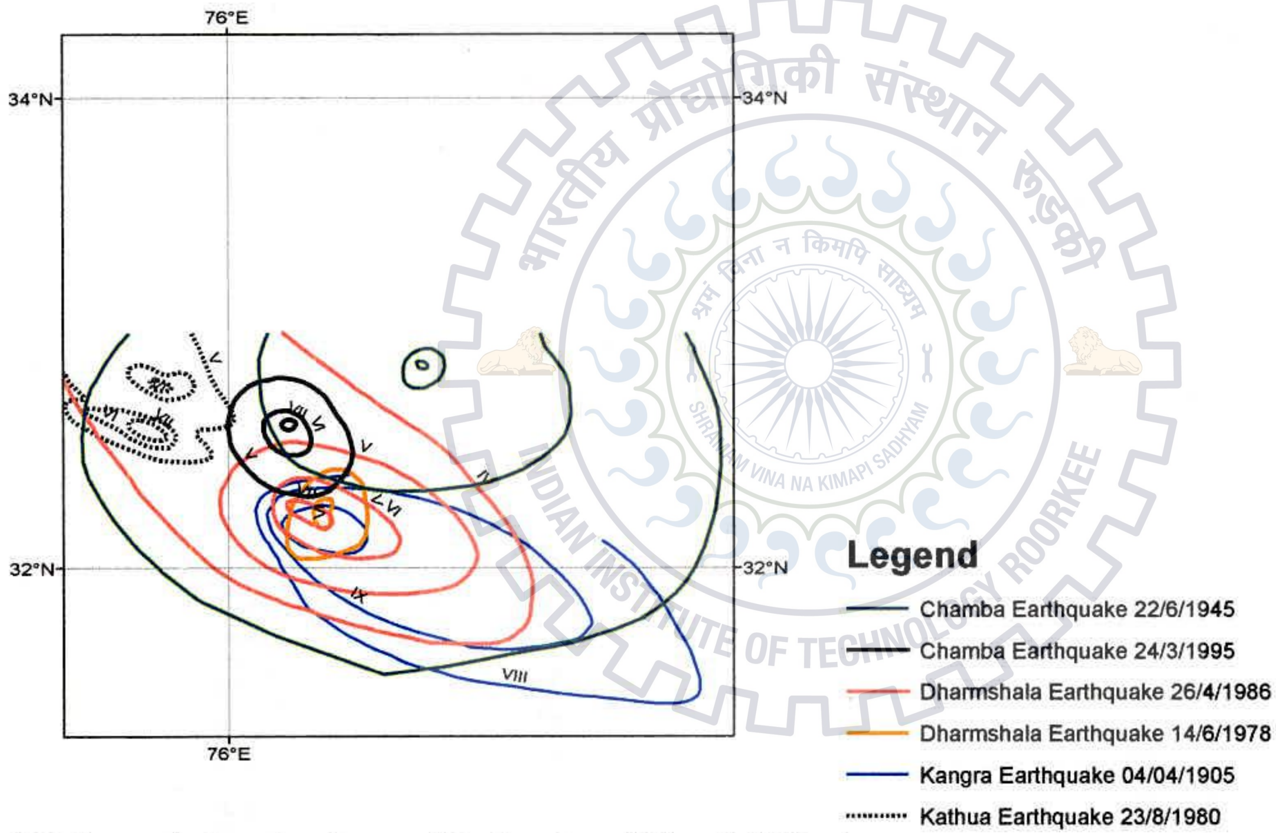


Fig 3.20 Composite Isoseismal map of Earthquakes of Himachal Himalaya

Composite Isoseismal map of Kumaon-Garhwal-Kinnaur Himalaya

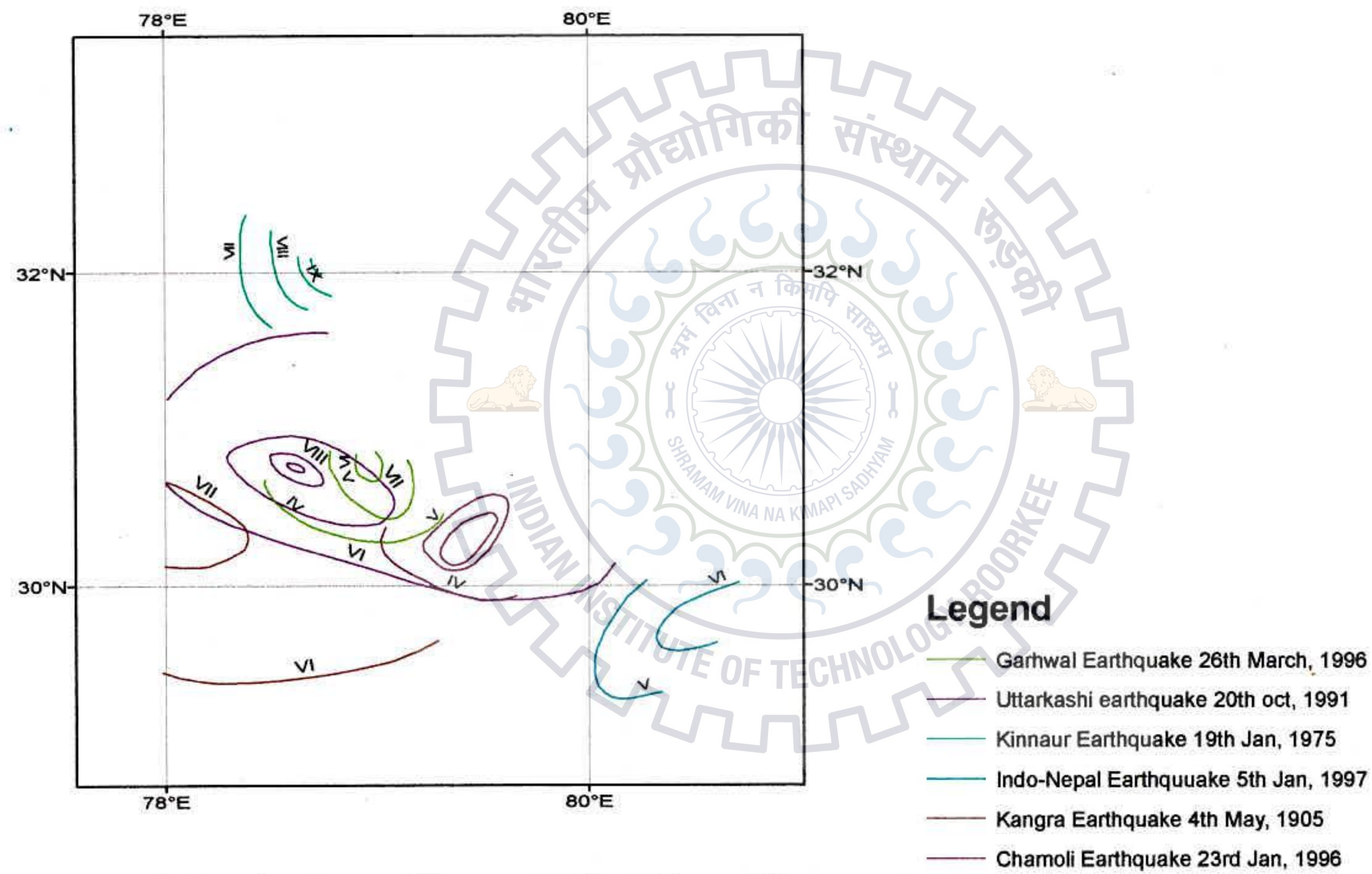


Fig 3.21Composite Isoseismal map of Kumaon-Garhwal-Kinnaur Hima

Fault plane solutions

The focal mechanism of an earthquake describes the deformation in the source region that generates the seismic waves. In the case of a fault-related event it refers to the orientation of the fault plane that slipped and the slip vector and is also known as a fault-plane solution.

SEISAT 01 Western Himalayan Syntaxis between Kohistan Arc and Potwar Plateau

Fault plane solutions of seven events are schematically shown. Five of these solutions are from Kohistan Arc, of which four exhibits dominantly thrust type mechanism and only one has significant strike-slip component.These fault plane solutions as well as detailed data collected during Pattan Earthquake reveal that the seismic activity north of MMT is related to north south convergence of the Indian and Asian plates, resulting in thrusting along the Himalayan belt. South of MMT, seismic events are related to Peshawar, Tarbela, Attock, Shinkiari, Jhelum and Mangla faults.The fault plane solution of the Nilore Earthquake, clearly deciphers a left lateral strike slip mode of rupture. However, towards east around Srinagar, fault plane solution indicates thrust type mechanism.Table 3.2.1 gives focal mechanism solutions for this area.

SEISAT 02 Tibetan Plateaus and Kashmir Ladakh Himalaya

Fault plane solution data of six seismic events are given in Table-2. Four events, lying in Pir Panjal Belt exhibit dominantly thrust type mechanism. This, along with preponderance of shallow focus events probably point towards the rupture mainly along subsidiary thrusts, connecting the main roof and the sole thrusts. In the northern part, earthquake events are mainly considered to be related to movements along Karakoram and Altyn Tagh Faults. However two fault plane solutions available from the part exhibit a different mode of rupture i.e. thrust rather than strikeslip type.Table 3.2.2 gives focal mechanism solutions for this area.

SEISAT 03 Trans - Himalaya between Karakoram and Altyn Tagh Faults

Fault plane solutions of five events has been considered, Seismicity is distinctly associated with the Altyn Tagh Fault and its southern splay in the lake lighten Fault segment. The main shock of 28th April , 1975(S No 1 in the table) along with its large aftershocks and the events of 1990 and 1992 indicate left lateral strikeslip mechanism but with significant amount of

normal component. Solutions for S. Nos 2 & 4 also indicate a similar mechanism associated with Lake lighten fault segment. Seismicity is prominent along the Bangong- Nu Jiang Suture. A few earthquakes also occur in the southern part of the area, in proximity to the Karakoram Fault segment. Table 3.2.3 gives focal mechanism solutionsfor this area.

SEISAT 05 Himachal Himalaya and adjoining Indogangetic plains

Five dominant thrust component (plot Nos 1, 2, 3, 4, & 5)while one has significant strikeslip component (plot no 6 a).Table 3.2.4 gives focal mechanism solutions for this area.

SEISAT 06 Himachal, Kumaon -Garhwal Himalaya & their Environ

Fault plane solutions of 14 events are schematically shown in the map (Table-2). Amongst these two solutions (plot No. 3 & 4) are from the events, closely associated with the dextral Karakoram Fault, but exhibit normal type mechanism with their nodal planes at high angle to the trend of the Karakoram Fault. The other solutions are from the two seismic zones of the Main Himalayan Belt. The trend of nodal planes of these two zones commonly coincides with the trend of the respective belts. These solutions bring out a difference of mechanism of rupture, operative in these two zones. In the Kinnaur Seismic Zone the solutions are commonly normal type with subordinate strikeslip component. On the other hand in Uttarkashi-Dharchula zone it is mainly thrust type with subordinate strikeslip component. These data reveal that the tensional regime prevails in the former zone, while it is dominantly compressional in the latter.Table 3.2.5 gives focal mechanism solutions for this area.

SEISAT 10 Indo Gangetic plains of Uttar Pradesh and uplands of Madhya Pradesh

Two solutions of 15th August, 1966 is schematically shown in the map. The trend of the nodal planes is different in these two solutions (Table 3.2.6). Both the solutions deduce a normal type of mechanism responsible for the rupture, indicating an extensional stress regime in foredeep area.Table 3.2.6 gives focal mechanism solutions for this area.

SEISAT 11 Nepal Himalaya and Adjoining Indo-Gangetic Plains

Fault plane solutions of two events of 1st June, 1965 and 16th October, 1973 are schematically depicted in the map. For the earlier event two sets of solution data (Table 3.2.7) are presented. While one set indicates a dominantly thrust type mechanism, the other indicates a strikeslip mode. The solution data for the latter event point towards a strikeslip mode of rupture. Table 3.2.7 gives focal mechanism solutions for this area.

SEISAT 12 Eastern Nepal Himalaya and Indo-Gangetic plains of Bihar

Fault plane solutions of 10 events shown in the table. Most of these solutions yield dominant strikeslip component with at least one nodal plane co-planar with the transverse structures of the area. All these evidences probably indicate that the transverse discontinuities have played a significant role in the recurrence of seismic events in the region.Table 3.2.8 gives focal mechanism solutions for this area

Table 3.2.1 Focal mechanism solutions, SEISAT 1

Plot no	Yr	Mo	Dt	Mb	NP1		NP2		P-AXIS		T-axis		B-axis		source	Beach Ball
					St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1	1963	09	02	5.1	145	70	325	20	25	235	65	55	0	325	Chandra,1978	
2	1965	01	29	5.7	72	32	309	71	56	253	22	19	25	120	Chandra,1978	
3	1972	09	03	6.3	127	29	316	61	16	40	74	228	02	131	Chandra,1978	
4	1972	09	03	5.6	138	30	308	60	15	38	75	218	0	308	Chandra,1978	
5	1972	09	04	5.7	127	35	307	55	10	37	80	217	0	307	Chandra,1978	
6	1974	12	28	5.9	284	39	124	53	08	206	78	72	09	295	Pennington 1979	
7	1977	02	14	5.2	177	69	290	24	38	122	15	244	20	348	Biswas and Dasgupta,1986	

Table 3.2.2 Focal Mechanism Solutions SEISAT 2

Plot no	Yr	M	Dt	Mb	NP1		NP2		P-AXIS		T-axis		B-axis		source	Beach Ball
					St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1	1963	06	26	5.3	295	88	115	02	43	25	47	205	00	295	Rastogi, 1974	
2	1965	06	22	5.7	318	56	138	34	11	48	79	228	00	318	-do-	
3	1967	02	20	5.3	149	45	315	46	00	52	83	145	07	322	Chandra, 1978	
4	1967	02	21	5.0	100	60	280	30	15	190	75	10	00	280	Rastogi, 1974	
5	1973	01	16	5.1	87	50	321	55	03	25	59	290	31	117	Chandra, 1978	
6	1973	10	24	5.3	168	36	06	56	10	82	78	304	04	175	Tandon &Shrivastva,1975	

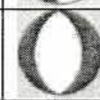
Table 3.2.3 Focal Mechanism Solutions SEISAT-03

Plot no	Yr	Mo	Dt	NP1		NP2		P-AXIS		T-axis		B-axis		source	Beach Ball
				St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1	1975	04	28	65	64	169	64	39	26	0	116	51	206	Molnar & Tapponnier,'78	
2	1975	05	19	350	60	245	68	40	205	05	299	50	36		
14	1975	06	04	180	64	288	60	42	140	03	233	48	327		
17	1986	07	06	263	74	357	76	21	220	01	129	69	37	HRV	
19	1992	04	05	62	52	339	81	33	28	20	285	50	165	HRY	

Table 3.2.4 Focal Mechanism Solutions SEISAT-05

Plot no	Yr	Mo	Dt	Mb	NP1		NP2		P-AXIS		T-axis		B-axis		Source	Beach Ball
					St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1	1975	12	11	5.0	166	74	346	16	27	265	63	75	0	164	Das Gupta et al.'82	
2	1976	01	7	5.3	150	58	338	34	12	243	80	48	04	152	Das Gupta et al.'82	
3	1978	06	14	5.0	168	72	348	18	26	258	64	78	0	348	Das Gupta et al.'82	
4	1980	08	23	5.2	293	10	140	81	36	226	54	56	05	319	HRV	
5	1980	08	23	5.2	298	12	126	78	33	214	57	38	02	305	HRV	
6(a)	1980	04	26	5.5	131	69	232	62	05	183	35	90	55	279	Rastogi'92	
7(b)	1986	04	26	5.5	299	19	153	74	28	235	60	77	10	330	HRV	
8	1968	11	05	4.9	325	24	164	60	22	242	67	86	08	336	Chaudhury et al.'74	

Table 3.2.5 Focal Mechanism Solutions SEISAT 06

Plot no	Yr	Mo	Dt	Mb	NP1		NP2		P-AXIS		T-axis		B-axis		source	Beach Ball
					St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1	1958	12	28	5.8	102	54	282	36	10	192	80	12	00	282	Tandon &Srivastava'75	
2	1964	09	26	5.8	305	17	114	73	28	207	62	19	03	115	Chanra'78	
3	1966	03	06	5.3	225	55	45	35	80	135	10	315	00	45	-	
4	1966	03	06	6.0	45	45	225	45	90	-	00	135	00	45	-	
5a	1966	06	27	6.0	313	28	116	70	18	212	71	09	07	120	-	
5b					200	74	292	81	18	157	05	65	72	318	Das Gupta et al.'87	
6a	1966	12	16	5.7	280	39	100	51	06	190	84	10	00	280	Chandra'78	
6b					178	70	275	72	28	137	02	47	62	315	Das Gupta et al.'87	
7	1975	01	19	6.2	360	50	180	40	85	270	05	90	00	00	Molnar & Chen'83	
8	1975	07	19	5.1	47	51	180	50	64	23	01	114	26	204	-	
9	1975	07	29	5.5	210	55	30	35	80	120	10	300	00	30	-	

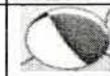
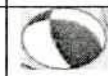
10	1977	02	19	5.4	199	58	344	37	70	153	11	276	16	09	HRV	
11a	1979	05	20	5.7	282	15	102	75	30	190	60	10	00	100	Ni & Barazangi'84	
11b					274	07	105	83	38	194	52	16	01	285	HRV	
12	1983	02	27	5.3	192	71	284	83	09	57	19	150	69	303	HRV	
13a	1986	07	16	5.6	278	17	152	80	33	231	53	79	14	330	HRV	
13b					288	34	165	70	21	244	54	108	26	334	Das Gupta'98	
14a	1991	10	19	6.4	317	14	12	78	32	207	57	14	06	1!3	HRV	
14b					349	26	100	80	30	210	50	342	23	105	Das Gupta'97	

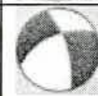
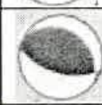
Table 3.2.6 Focal mechanism solutionsSEISAT 10

Plot no	Yr	Mo	Dt	Mb	NP1		NP2		P-AXIS		T-axis		B-axis		source	Beach Ball
					St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1(a)	1966	8	15	5.6	312	31	132	59	76	222	14	42	0	132	Molnar and Tapponnier 1978	
1(b)	1966	8	15	5.6	101	30	281	60	75	191	15	11	0	101	Chandra, 1977	

Table 3.2.7 Focal Mechanism SolutionsSEISAT 11

Plot no	Yr	M	Dt	Mb	NP1		NP2		P-AXIS		T-axis		B-axis		source	Beach Ball
					St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1a	1965	6	01	5.3	267	40	123	56	9	197	70	84	19	302	Rastogi, 1974	
1b	"	"	"	"	224	80	318	65	26	177	10	273	63	25	Das Gupta, 1987	
2	1973	10	16	5.0	182	72	279	74	24	140	4	52	65	315	Chandra, 1978	

Table 3.2.8 Focal mechanism solutions, SEISAT 12

Plot no	Yr	Mo	Dt	Mb	NP1		NP2		P-AXIS		T-axis		B-axis		source	Beach Ball
					St	Dip	St	Dip	PI	Az	Pi	Az	Pi	Az		
1	1970	02	26		206	65	29	86	20	165	15	70	64	306	Das gupta, et. al 1987	
2	1974	03	24		210	58	308	76	32	175	10	78	54	330	ND	
3	1974	09	27		86	77	181	72	03	135	22	43	66	233	Dasgupta, et. al 1987	
4	1975	01	31		213	60	304	88	23	172	18	74	60	310	Dasgupta, et. al 1987	
5	1978	02	10		224	56	316	86	28	184	20	83	56	322	Dasgupta, et. al 1987	
6	1978	10	04		246	60	344	74	32	208	08	114	55	08	Dasgupta, et. al 1987	
7	1986	01	10		140	46	38	78	40	349	20	96	43	206	HRV	
8	1988	04	20		212	72	113	68	30	72	02	340	60	246	Dasgupta, 1993	
9	1988	08	20		210	54	305	84	33	174	20	74	54	314	Dasgupta, 1993	
10	1988	10	29		309	30	106	62	16	205	71	352	10	112	HRV	

CHAPTER 4

MAJOR DESTRUCTIVE EARTHQUAKES

This chapter deals with major destructive earthquake and several aspects of seismicity related to them. Earthquakes are taken from time range 1833 to 1998 and magnitude range 5.0 to 8.3.These were selected on the basis that it was described in the SEISAT atlas, or their isoseismal map or fault plane solution was given in SEISAT.These earthquakes are arranged in chronological order. The column for isoseismal map gives figure number in this study, as per chapter 3. List of major destructive earthquake in the study area is given in Table 4.1

Table 4.1 Major destructive Earthquake from SEISAT Sheet

SN	YY	MM	DD	Lat	Long	Mag	Depth	Geographical Identifier	SEISAT	Isoseismal Map	FPS
1	1833	08	26	-	-	-	-	Nepal earthquake	12	3.01	-
2	1885	05	30	34.12	74.61	7	-	Kashmir Earthquake	1	3.02	✓
3	1905	04	04	32.30	76.30	8.0	35.0	Kangra Earthquake	5	3.03	-
4	1916	08	28	30.00	81.00	7.5	-	-			
5	1934	01	15	26.50	86.50	8.3	-	Bihar-Nepal earthquake	12	-	-
6	1945	06	22	32.50	76.00	6.5	60	Chamba Earthquake	5	3.08	-
7	1958	12	28	29.50	80.00	6.0	-	Kakpot Earthquake			✓
8	1963	09	28	-	-	-	-	Badgam Earthquake	1		✓
9	1967	02	20	33.63	75.33	5.5	20	Anantnag Earthquake	2		
10	1974	12	28	-	-	-	-	Pattan Earthquake	1		✓
11	1975	01	19	31.93	78.52	5.8	49	Kinnaur Earthquake	6	3.09	✓
12	1978	06	14	32.23	76.61	5.0	7	Dharamshala Earthquake	5	3.10	✓
13	1980	08	23	32.96	75.75	5.2	3	Kathua Earthquake	5	3.11	✓
14	1986	04	26	32.15	76.40	5.5	23	Dharamshala Earthquake	5	3.12	✓
15	1988	08	20	26.72	86.63	6.6	65	Bihar - Nepal earthquake	12	3.13	✓
16	1991	10	19	30.77	78.79	6.8	13.2	Uttarkashi Earthquake	6	3.14	✓
17	1995	03	24	-	-	-	-	Chamba Earthquake	5	3.15	-
18	1996	01	23	-	-	-	-	Chamoli Earthquake	6	3.16	-
19	1996	03	26	-	-	-	-	Garhwal Earthquake	6	3.17	-

4.1.Nepal earthquake of 26th August, 1833

The earliest of these is the Nepal earthquake of 26th August, 1833. The epicenter of this event lies close to Katmandu. Estimates of moment magnitude based on reported intensities indicate that the earthquake was of 7.5 < M <7.9. This event affected around I million sq. km. region of northern India, Nepal and Tibet and caused landslides, rock falls and destruction of 4600 dwellings. It took around 500 human lives.Isoseismal map given in Chapter 3, Fig 3.01

The earthquake damaged Kathmandu, and although it was felt in Chittagong to the SE and Delhi to the SW it was hardly felt in Lhasa to the north. Three shocks occurred with increasing magnitude. Its magnitude has been assessed at 7.3 < Mw < 7.7.The earthquake is mentioned in T. Oldham (1883), and the felt-area isoseismal contour was first drafted by R. D. Oldham (1899). These were repeated in Dunn et al., (1935) in the report on the 1934 Bihar Nepal earthquake. It is probable that the rupture area of the 1833 earthquake was contiguous with the NW edge of the 1934 Mw8.1 rupture, but the rupture areas of neither earthquake are known for certain. The 2015 earthquake ruptured part of the same area again.

Lat N	Long E	Mw	Source
28.0	86.0	7.7	Bilham, 1995
27.7	85.7	7.61	Ambraseys & Douglas, 2004
27.55	85.11	7.3	Szeliga et al., 2009
28.2	85.5	8.0	National Geophysical Data Center (NGDC)

4.2.Kashmir Earthquake 30th May, 1885

Its epicenter was at Jampur, 19.5 km west of Srinagar. This event took about 3000 lives and caused wide spread damage around Srinagar. Isoseismal map given in Chapter 3, Fig 3.02.

The following description of this earthquake is after Mukhopadhyaya and Dasgupta (2013), Descriptive account along with an isoseismal map for the earthquake of 30 May AD 1885 [table 1; No. 14] was published in the GSI Records (Jones 1885a, 1885b); Bashir et al. (2009); estimated EMS (European Macroseismic Scale) intensity VI—WI (Bilham et al. 2010) and assigned M = 6.2-6.3 (Ambraseys & Douglas 2004; Szeliga et al. 2010). According to Jones (1885a, 1885b):

In spite of the comparative mildness of the shock, the loss of life was very great, being in round numbers about 3000. The cause of this is to be looked for in the very insecure manner of building in vogue. In a very considerable number of the cases in which huts were damaged, the supports of the roof had given way and allowed it to subside, frequently carrying the walls down with it leaving only a mass of rubbish to indicate the spot where the house had stood.

The greatest damage has been done over an irregularly elliptical area, the long axis of which is 10 miles and the short axis 6 miles long, and the superficial area about 47 square miles, and nearly symmetrically disposed about the seismic vertical. Within this area, the destruction was complete, whole villages being almost entirely destroyed and many lives lost. This corresponds to the meizoseismal (Intensity VII + in MSK scale) area of Mallet.

The area outside this, corresponding to Mallet's first isoseismal, includes the area within which large portions of villages and towns were thrown down and persons killed. This is included by a line passing east of Srinagar through Magaon south of Baramula and across the Jhelum near Gingal, then passing north of Sopur and round again to the south of Srinagar. It includes an area of about 500 sq miles.

Outside is again another area of about 3000 sq miles (second isoseismal) including those places from which slight damage to buildings etc. is reported to have occurred, but it is probable that even within this area there was some loss of life. It is indicated on the map by the broken line passing north of Gurais to east of Titwal on the Kishengunga river, west of Chikar, southeast of Bagh, and south of Punch, at or near all of which some damage to buildings, chiefly forts, is reported. From Punch to Gurais there are no reports, and the true course of the line is uncertain.

Area under third isoseismal is large, including the places where the shock is reported to have been perceived viz., Peshawar, Gilgit, Shimla, Sabathu, Dalhousie, Lahore etc. A large landslip occurred at Larridur, a place about 7 miles south of Baramula. This village is situated upon a hill lying NW-SE, composed of slightly hardened Karewa clays resting upon sandstones and dipping to NE at 5-10°. Above the clay is surface soil of varying thickness. The upper 30 feet of clay and surface soil has slipped along to the dip, exposing a fresh smooth surface of clay. The line of parting ran along the length of the hill, and a fissure has been formed along this line varying in width from 30 feet at the SE end to about 500 yards at the NW end and with a length of about half a mile.

In many places, as at Patan, Dubgaon (at the junction of the Jhelum and Pohra rivers), along the banks of the river at and above Baramula, numerous fissures were formed in the alluvial soil and all running roughly parallel to river banks or else across the slope of hills. In the neighborhood of many of these fissures water and fine sand were thrown out, and the villagers stated that there was a strong sulphureous smell given off from the sand for several days. In one case at Nila, near Patan, an inflammable gas without odor being slowly evolved. Several springs were affected by the earthquake, the flow of water being increased for periods of time ranging from a few hours to as many as eight days.

The country occupied by the meizoseismal area is entirely composed of recent alluvium, and that within the first isoseismal line is almost entirely of the same character, the Karewa beds (Pleistocene alluvium) coming into the NW of the area in the neighbor-hood of Baramula, and down the river below Baramula the alluvial deposits are under-laid at short depth by the more indurated rocks of the Panjal system, which also appear to the east of Srinagar.

Lat N	Long E	Mw	Source
34.1	74.8		Jones 1885
34.12	74.61		BAN
		6.2-6.3	(Ambraseys & Douglas 2004; Szeliga et al. 2010)

4.3.Kangra Earthquake of 4th April, 1905

The next important and the most damaging earthquake within the study area is that of the 4 April 1905 Kangra earthquake. This is one of the four great earthquakes of the Himalayan region which took a toll of 20,000 human lives and caused collssal loss in the form of complete damage to buildings and generations of numerous landslides and earth fissures. Isoseismal map is given in Chapter 3, Fig 3.03.

The following description of this earthquake is after Mukhopadhyaya and Dasgupta (2013). It is located to the southeast of the Kashmir valley. Details on this earthquake are available in (GSI Records, XXXII, Pt 4 1905), Middlemiss (1910) and several other published documents. Recent research articles (Ambraseys & Douglas 2004; Hough et al. 2005), among others, added several unknown facts to our knowledge base.

There are two separate epicentral locations of this earthquake: one with 33.00N: 76.00E, focal depth 50 km (Centennial Catalogue by E. R. Engdahl and A. Villasenor 2002; Ambraseys & Douglas 2004) and the other with 32.30N: 76.20E (IMD source). For this paper, we adopted the epicentral location of former (see table 1) for its wider acceptance. According to Middlemiss (1910), the innermost isoseismal X [(R-F Scale). ≈ IX+ in MSK Scale)] encloses an area of about 200 sq miles. Its curve roughly cuts Dharamsala, Rehlu, Daulatpur, Bawarna and Palampur. It includes much of the Kangra valley and portions of the lower slopes of the Dhauladhar range. The next isoseist IX VII—IX in MSK Scale) though less well defined encloses an elliptical area of about 1600 sq miles. On the west and south the isoseismal was located with considerable accuracy passing through Shahpur, Ranital and Sujanpur; but further ESE by Mandi and Manglaur it is less well defined. The isoseist VIII (≈VII—VIII in MSK Scale) forms two separate close curves: one in the Kangra—Kulu area and the other, a smaller one, in the Dehradun—Mussoorie area. The former forms an elliptical area of about 2150 sq miles including localities Telokenath, Jawalamukhi, Suket, Rampur, Manikaran, Kot, etc.

Lat N	Long E	Mw		Source
33.00	76.00			Centennial Catalogue by E. R. Engdahl and A. Villasenor 2002; Ambraseys & Douglas 2004)
32.30	76.20		8	IMD
			7.8	Bilham, R. (2000)
33.00	76.00			Utsu, T. R. (2002)
32.30	76.25	7.8		Ambraseys and Bilham (2000)

4.4.Earthquake of28th August, 1916

The largest earthquake of this region was that of 28th August, 1916 which has caused heavy damage to the civil structures in Dharchula village. (Dasgupta 1992)

Lat N	Long E	Mw	M_s	Source
30.0	81.0		7.7	National Geophysical Data Center (NGDC)
30.00	81.00		7.5	IMD

4.5.Bihar-Nepal earthquake of 15th January, 1934

The great Bihar-Nepal earthquake of 15th January, 1934 (Ms-8.3, Mb 7.8, Mo - 1 1 x102°Nm) devastated a huge area of north Bihar and adjacent Nepal. This event had caused death of around 10,000 people. Bhaktapur, Kathmandu and patan were affected and large scale damage occurred. Many buildings collapsed and roads were damaged in Kathmandu.

Lat N	Long E	Mw	M_b	M_s	Focal Depth	Source
26.30	86.30			14.8 km		GSI (1934)
26.50	86.50		7.8	25 km	8.4	Richter (1958)
26.77	86.76	8		35 km		Engdahl & Villasenor (2002)
26.50	86.50		7.8		8.3	Abe (1981)
26.77	86.69					Seeber & Armbruster (1981)
26.773	86.762	8				National Geophysical Data Center (NGDC)

4.6.Chamba Earthquake of 22nd June, 1945

Chamba Earthquake of 22nd June, 1945 also caused considerable damage to property.Isoseismal map given in Chapter 3, Fig 3.08

Lat N	Long E	Mw	M_s	Source
32.60	75.90		7.5	Srivastava et al. (1987)
32.50	76.00		6.5	IMD

4.7.Badgam Earthquake 2nd Sep, 1963

Epicenter of Badgam earthquake is Lat 33.9^0 N, Long 74.7^{0}E. Its epicenter is 5 km south of Badgam. The tremors damaged over 2000 houses resulting in the death of several persons.This earthquake also studied by Srivastava et al.

4.8.Anantnag earthquake of 20th Feb, 1967

Macro seismic survey data of Anantnag earthquake of 20. 02.1967 indicate that the epicentral intensity was VII on MM scale and the isoseismal elongation was N-S .This earthquake caused various grades of damage in a 250 sq km area where 10% of the houses suffered total or partial collapse.

4.9.Pattan Earthquake 28th Dec, 1974

Epicenter of Pattan earthquake isLat 35.1^0 N, Long 72.9^{0}E. Affected a population of around 60000 in the areas of Swat and Indus Kohistan

Lat N	Long E	Mw	Source
35.1	72.9	6.2	USGS

4.10.Kakpot Earthquake of 28th December, 1958

Kakpot Earthquake of 28th December, 1958, resulted in collapse of over a dozen houses and generation of earth fissures.This earthquake is called the Kakpot earthquake. It had a surface wave magnitude (Ms) of 6.0 (Dasgupta,2000) and a moment magnitude (Mw) of 6.2 is obtained using empirical relations ,1995). More than a dozen buildings collapsed (Dasgupta,2000). Fissures and landslides (Mathur,2000) were generated in an area within 150 kilometres (Mathur,2000) of Kakpot.

Lat N	Long E	Mw	Source
29.50	80.00	6.1	Dasgupta, 2000

4.11.Kinnaur Earthquake of 19th January, 1975

Kinnaur Earthquake of 19th January, 1975, caused complete collapse of 278 houses in 23 villages in Spiti and Pare Chu valleys which also took a toll of 42 human lives.Isoseismal map given in Chapter 3, Fig 3.09

The areas most strongly affected by the earthquake were the districts of Kinnaur and Lahaul-Spiti. The worst affected villages were in the Parachu and Spiti river valleys. The village of Karauk showed the greatest degree of damage, with no building being unaffected. Buildings sited on slopes or at the base of slopes were not only affected by the shaking but by boulders falling from the hills above them.(Singh, 2011)The performance of the different types of residential buildings varied greatly. Houses made from mud, either directly or as sun-dried bricks showed damage over a wide area (up to 100 km from the epicenter) and those in the epicentral area were often severely damaged. Unreinforced masonry structures were also badly affected, particularly those made of "random rubble stone masonry" (RRSM) with mud mortar, some of them having collapsed completely. The best performing buildings were barrack type houses constructed from corrugated iron covering a timber frame, which generally showed little or no damage.(Singh, 2011).The many monasteries and temples in the area were mostly badly damaged. They were often constructed with mudbrick or RRSM walls and had heavy roofs. (Singh, 2011)Strong vertical motion during the earthquake led to excessive loads on the upper part of the supporting walls causing them to bulge outwards. (Singh, 2011)There were many landslides, rockfalls and avalanches triggered by the earthquake.(Singh, 2011).This earthquake also studied by Khatri et al. (1978)

Lat N	Long E	M_b	Source
32.38	78.49	7.5	Singh et al. (1976)
32.57	78.52	5.8	ISC

4.12.Dharamshala Earthquake of 14th June, 1978

Dharamshala Earthquake of 14th June, 1978 had resulted in the development of cracks in a number of buildings in Dharamshala town.Isoseismal map given in Chapter 3, Fig 3.10

Lat N	Long E	M_w	M_b	Source
32.30	76.25	7.8		Ambraseys and Bilham (2000)
32.23	76.61		5.0	ISC

4.13.Kathua Earthquake of 23rd August, 1980

Kathua Earthquake of 23rd August, 1980 was a complex event which had epicenters at Bhaddu-Dudwara and Lohai-Malar areas. There was considerable damage in these areas including loss of 12 human lives, caused considerable damage to buildings and resulted in the development of earth fissures.Isoseismal map given in Chapter 3, Fig 3.11

Lat N	Long E	M_w	M_b	Source
32.96	75.75		5.2	ISC

4.14.Bihar - Nepal earthquake of 20th August, 1988

The Bihar - Nepal earthquake of 20th August, 1988 (Ms 6.6, Mb 6.4, Mw 6.7, Mo 2.3 x 1019Nm) claimed about 1,000 lives and destroyed/badly damaged about 50,000 buildings. Movement along EPF is considered to have triggered the latter two events.Isoseismal map given in Chapter 3, Fig 3.12

Nearly 900 people were killed in eastern Nepal and the bordering district of Bihar, India. Damage was also reported from Kathmandu and Sikkim. It was felt over much of northern and eastern India and much of Nepal and as far as New Delhi.

This earthquake also studied by Brijesh (1990) and details are given in Damage Survey Report from Department of Earthquake Engineering and Reconnaissance Report on the August 21,1988 Earthquake in the Nepal-India border region

Lat N	Long E	M_w	M_b	Source
26.755	86.616			NEIC
26.71	86.62	6.9		ISC
26.775	86.616		6.6	National Geophysical Data Center (NGDC)

4.15.Dharamshala earthquake of 26th April, 1986

Dharamshala earthquake of 26th April, 1986 took a toll of three human lives, caused considerable damage to buildings and resulted in the development of earth fissures..Isoseismal map given in Chapter 3, Fig 3.13

Lat N	Long E	M_w	M_b	Source
32.15	76.40	5.0		Kumar and Mahajan (1990)
32.15	76.40		5.5	ISC

4.16.Uttarkashi Earthquake 19th October, 1991

Caused extensive damage of civil structures and took 768 human lives, besides injuring 5066 people.Isoseismal map given in Chapter 3, Fig 3.14.768 people were killed and nearly 5,000 injured in this earthquake in Uttarkashi district. Some 18,000 buildings were destroyed in the Uttarkashi-Chamoli region. Landslides and rockfalls were widespread in the Gharwal Hills. Tremors were felt over a wide area of northern India, western Nepal and Pakistan. Minor damage was reported from New Delhi and Chandigarh.This earthquake also studied by Valdiya (1991) and report given by Geological Survey of India, Special Publication No. 30(1992)

Lat N	Long E	M_w	M_s	M_b	Source
30.76	76.79		6.4		Narula et al. (1995)
30.770	78.790				NEIC
		6.8			Dasgupta, 2000
30.77	78.79			6.4	ISC

4.17.Chamba Earthquake of 24th March, 1995

Chamba Earthquake of 24th March, 1995 caused partial collapse and development of cracks in the buildings.Isoseismal map given in Chapter 3, Fig 3.15

Lat N	Long E	M_w	M_b	Source
32.66	76.16		4.9	Mahajan (1997, 1998)

4.18.Chamoli Earthquake of 23rd January, 1996

Earthquake resulted in only minor damage.Isoseismal map given in Chapter 3, Fig 3.1

4.19.Garhwal Earthquake of 26th March, 1996

Earthquake had caused damage to poor type structure. Isoseismal map given in Chapter 3, Fig 3.17

Lat N	Long E	M_b	Source
30.69	79.10	4.6	GSI Report (2001)

TECTONIC

The NW and central Himalayas and the adjoining region are associated with the underthrustingof rock blocks resting on the Indian plate resulting into development of two regionally northerly dipping convergent zones; the MCT and MBT.The MBT is a series of thrusts that separates the lesser Himalaya from the sub-Himalaya belt (Valdiya 1980). The MCT at the base of the central crystalline zone dips northward separating the Higher Himalaya from the Lesser Himalayas (Gansser 1977) and it may be noticed that the MCT is terminated against transverse Kishtwar Fault (KF) in Jammu and Kashmir One of the most important transverse faults in the western Himalaya is the Sundernagar Fault (SNF) also called Manali Fault which is dextral in nature and traverses extending from Higher Himalaya to Frontal Belt. The subsurface Mahendragarh–Dehradun Fault (MDF), Moradabad Fault (MF), and Great Boundary Fault (GBF) are also important structural elements recognized in the Gangetic foredeep.

Political aspects, important physiographic features and tectonics of the study area, as per SEISAT sheets isdiscussed in this chapter.Table 5.1 gives 53 named tectonic units in the form of faults, thrusts, grabens, lineaments, fold belts, subsurface ridges, basins, syntaxes and basins.

Table 5.1 Alphabetical listing of tectonic units in the study area

S No	Tectonic Unit	Type	Acronym	SEISAT Sheet No
1.	Altyn Tagh Fault	Fault		03
2.	Attock fault	Fault		01
3.	Bikaner basin	Basin		04
4.	Chittaurgarh Lineament	Lineament		09
5.	Dehradun fault	Fault		05
6.	Delhi fold belt	Belt		09
7.	Delhi Ridge	Ridge		04
8.	Drang Thrust	Thrust		05
9.	East Patna Fault	Fault	EPF	12
10.	Everest lineament	Lineament		12
11.	Frontal belt	Belt		01
12.	Gaurishankar lineament	Lineament		12
13.	Great Boundary Fault	Fault	GBF	10,09
14.	Jhelum fault	Fault		01,04
15.	Judi Fault	Fault		12
16.	Jwalamukhi thrust	Thrust		05
17.	Kallar Kabar Fault	Fault		05

18.	Karakoram Fault,	Fault		02,03
19.	Kishtwar Fault	Fault		02
20.	Kung Co Graben	Graben		12
21.	Lahore Ridge	Ridge		04
22.	Lucknow Fault	Fault	LT	10
23.	Machilpur Lineament	Lineament		09
24.	Mehendragarh fault	Fault		05
25.	Main Boundary Thrust	Thrust	MBT	01,02,11,12
26.	Main Central Thrust	Thrust	MCT	05,11,12
27.	MainFrontal Thrust	Thrust	MFT	12
28.	Main Karakoram Thrust	Thrust	MKT	01
29.	Main Mantle Thrust,	Thrust	MMT	01
30.	Mirganj Graben	Graben		11
31.	Moradabad Fault	Fault		10
32.	Munger Saharsa Ridge Fault	Fault	MSRF	12
33.	Nagaur Basin	Basin		04
34.	North Almora Thrust	Thrust	NAT	11
35.	Punjab foredeep basin	Basin		04
36.	Peshawar Basin	Basin		01
37.	Reasi Thrust	Thrust		04
38.	Ropar Fault	Fault		05
39.	Salt Range Thrust	Thrust		04
40.	Shinkiari fault,	Fault		01
41.	Sitamari High			12
42.	Sargodha ridge	Ridge		04
43.	South Almora Thrust	Thrust	SAT	11
44.	Sundernagar Fault	Fault		05
45.	Trans - Himalayan tectogen	Tectogen		01,03,06
46.	Tarbela Fault	Fault		01
47.	Tarim basin	Basin		03
48.	Takhola Graben	Graben		11,12
49.	Vaikrita Thrust	Thrust	VT	05
50.	Vindhyan basin	Basin		09
51.	Western Himalayan Syntaxes	Syntaxes		01
52.	West Patna Fault	Fault	WPF	12
53.	Yamuna Tear fault	Fault		05

SEISAT SHEET 01 Western Himalayan Syntaxis between Kohistan Arc and Potwar Plateau

Political aspects

Important physiographic features in the northern part of the area arc the Hindukush Mountain, Pamir Plateau and Great Karakoram Range. South of this tract lie the Peshawar and Kashmir basins and the Potwar Plateau. This sheet incorporates parts of India, China, Pakistan, Afghanistan and erstwhile USSR. Some of the important localities are Gilgit, Mardan, Attock, Rawalpindi, Punch, Baramula and Srinagar. The major rivers of this area are Abi Panja, Mastuj, Indus, Jhelum and Chenab.

Important physiographic features

Hindukush Mountain, Pamir Plateau and great Karakoram Range are in the northern part of the area Peshawar and Kashmir basins and the Potwar Plateau South of this tract lie in the South of this tract.

TECTONICS

Trans - Himalayan Tectogen

The northernmost tectonic unit is the Trans - Himalayan tectogen which towards east (in Seisat-2 &3) comprises the litho-packets north of the Shyok Suture. This is followed towards south by the accretionary complex, late to post tectonic granitoids, accreted arc with sediments and ophiolite of the Koshistam Arc.

Kashmir Basin

Further south in Kashmir Basin, basic volcanics, high (F)F and low (F)FC grade complexes (tectonically reworked during Himalayan orogeny), poorly metamorphosed assemblages (affected by Himalayan fold-thrust movement), granitoids, and alluvial fill in superposed basins are recorded, while in the Potwar basin all other packets are present, except basic volcanics and high grade crystallines (F)F.

Frontal Belt

The southernmost frontal belt exposes only cover rocks (F), affected by terminal phase of the Himalayan Orogeny, the alluvial fill in the superposed basin.

Western Himalayan Syntaxes

The northwestern part of this sheet is occupied by the most spectacular feature of the Himalayan orogeny, the Western Himalayan Syntaxes. In the outer belt this syntaxial bend is reflected by the Jhelum re-entrant which is flanked on either side by the Kashmir and Peshawar basins.

From north to south three main thrusts, separating the major tectono-stratigraphic belts are present.

Main Karakoram Thrust (MKT)

The northernmost is the Main Karakoram Thrust (MKT) which separates the Hindukush-Karakoram belt from the island arc of Kohistan.

Main Mantle Thrust (MMT)

Towards south, the latter is separated from Peshawar and Kashmir basins by the Main Mantle Thrust (MMT).

Main Boundary Thrust (MBT)

Southernmost is the Main Boundary Thrust (MBT) which separates the main Himalayn package from the sedimentary sequence of the frontal belt.

Jhelum Fault

Among the major neotectonic faults, the Jhelum fault is regionally the most extensive. It is a N-S trending left lateral wrench fault which separates Peshawar Basin from the Kashmir Basin. Its conjugate set is the Mangla Fault which is a right lateral wrench fault.

Tarbela and Shinkiari faults

Subparallel to Jhelum Fault are the Tarbela and Shinkiari faults.The former is located well within the Peshawar Basin, while the latter has developed along the eastern margin of the basin. Both these represent fault zones which cut across the alluvium and resulted in stream offsets and dislocation of strata.

Peshawar and Attock faults

Besides these transverse faults,two major faults Peshawar and Attock faults,subparallel to the Himalayan trend also display neotectonic activity.

Gravity value decreases from foothill region to the higher Himalayan. Highest (-150 m Gal) and lowest (-500 m Gal) gravity contours pass through the southern and northern parts respectively. Towards south gravity contours have a general northwesterly trend which swings towards east-northeasterly over the Kohistan arc. This swing coincides approximately with the MMT.

The crustal configuration across Himalaya (Srinagar to Gilgit) is deduced from the DSS study. The general crustal picture along this profile shows a depression in the Moho boundary below Kashmir valley and an upwarp below Nangaparbat region. This upwarp of Moho might be responsible for the uplift of the Nangaparbat massif. Besides, two deep seated faults are also postulated from this study.

SEISAT SHEET 02 Tibetan Plateau and Kashmir- Ladakh Himalaya

Important physiographic features

Comprising regions of India and China, Great Karakoram Range in the north, Ladakh range in the central part and Zanskar and Pir panjal ranges in the south, The important localities are Anantnag, Doda Kargil and Leh. Major drainages are Chenab. Indus. Karkandor and Shyok

Tectonics

Trans Himalayan tectogen

The northernmost tract, north of the Shyok Suture is occupied by lithopackets of Trans Himalayan tectogen, which continues from west (SEISAT-1).

Towards south, this belt is followed by tectonic packages comprising accretionary complex, accreted arc with sediment, ophiolite and Ladakh Granitoid. This is bound on either side by Shyok Suture (SS) and Indus Suture Zone (ISZ).

Main Himalayan Belt

Further south upto Main Boundary Thrust (MBT) litho-units of the main Himalayan belt are exposed. Major components are low grade cover sequence (F) FC and high grade complex (F) F, tectonically reworked during Himalayan Orogeny, granitoids and basic rocks, and alluvial fill of the superposed basins (cs). Besides, in a Klippe zone, ophiolite and accreted arc with sediments are exposed. South of MBT the terrain is mainly occupied by rocks of the frontal belt (F) with tectonic veneers of (F) FC.

Karakoram Fault

The most conspicuous mega structural element is the dextral strikeslip Karakoram Fault, forming the eastern boundary of the Pamir syntaxis and the western boundary of the Tibetan block.

This fault extends for almost 1000 km from central Pamir to Kumaon Himalyan. Conjugate to this, is the Altyn Tagh Fault. Towards south the SS separates the Karakoram Belt from the Indus-Shyok Belt. Further south the ISZ marks the northern limit of the Main Himalayan Belt, within which MCT and MBT are considered to be the two most regionally extensive tectonic discontinuities. Of the several transverse faults of limited surface extension, **kishtwar** fault (also known as Suru Fault) is the most prominent one.

SEISAT SHEET 03 Trans-Himalaya between Karakoram and Altyn Tagh Faults

Important physiographic features

Well-known geographic features of this terrain are Tibetan Plateau.Towards north Kunlun Range and Tarim Basin and towards south Pangong Lake. This sparsely populated, high altitude region has only a few settlement such as Tak Morpa and Huzakhar. Major drainages are Chira, Indus, Karakashand and Shyok

Tectonics

Trans-Himalayan tectonic packet along with granitoid bodies occupies the major area.
Other lithotectonic packets, occurring along the southern margin include high grade complexes (F) F, low grade litho-assemblage (F)C, ophiolite and rocks of the accretionary complex.

Karakoram and Altyn Tagh faults

Major tectonic elements are Indus and Bangong-Nu Jiang sutures and the right lateral Karakoram and Altyn Tagh faults.The break in slope between the Tibetan Plateau and the Tarim basin is the geomorphic depiction of the Altyn Tagh Fault. The left lateral strikeslip Altyn Tagh Fault, considered as one of the spectacular tectonic element of the terrain, extends for a length of about 1500 km. it is one of the major continental strikeslip fault of the world and can be compared in length and probably in rate and amount of slip with the San Andrreas Fault of California. From around longitude 83^0E, towards this present sheet this fault branches out. The main fault segment between 81^0E-83^0E longitudes has E-W trend (east of this area) which slightly veers in the present sheet to ESE-WNW. The southern splay, extending towards SW/SSW direction, encompass short N-S half garben. In this sheet the Lake Lighten fault and other faults along with at least two N-S trending Quaternary faults, represent the southern splay of the Altyn Tagh Fault. One of these half garben is formed by the Beng co Fault. This fault cuts the extinct glacier valleys and forms triangular faceted spurs. Movement along this fault has also resulted in the regression of the shoreline of the lake Ze Co, overprinting the earlier terminal moraines.

SEISAT SHEET 04 North Rajasthan and Punjab Sector

Important physiographic features

The sheet comprises the vast Indo-Gangetic alluvial tracts of India and Pakistan. The important localities in Indian territory are Jammu, Amritsar, Firozpur, Sriganga Nagar and Suratgarh. The major rivers, belonging to the Indus basin include Jhelum, Chenab, Ravi and Sutlej.

Tectonics

Major part of the sheet is covered by alluvial fill of the foredeep (cf) and pericratonic fill on the attenuated continental crust (cpr).

The tectonic packets in the northern part comprise poorly metamorphosed/unmetamorphosed litho-assemblages folded during Himalayan fold thrust movement (F) C and rocks of the frontal belt affected by fold thrust movement during terminal phase of Himalyan orogeny (F). Besides, alluvial fill in the superposed basins (cs) is also present in the foothills of the Himalaya. In the northeastern corner (F) C is overlain by (F) FC.

Salt Range Thrust and Resai Thrust

The main structural feature of the sub-Himalaya is represented by the northerly dipping thrusts, viz, salt range Thrust and Resai Thrust. The latter is the eastern extension of the Jwalamukhi Thrust, shown in SEISAT 05.

The Salt Range Thrust has a configuration approximately parallel to the Jhelum course. The Salt Range is considered to be an upthrown block of a low angle thrust fault, essentially bedding parallel. This thrust is postulated as a decollement structure, formed due to contrasting rheology of litho-packets on either side of the discontinuity plane.

Geological evidences, particularly from the eastern part of the Salt Range, indicate that uplift has mainly occurred in the last 1 m.y, thus pointing towards the neotectonic activity along the thrust plane.

Jhelum fault

Several other faults and lineaments are also present in the area, of which Kallar Kabar Fault and southern extension of Jhelum fault are important. The former exhibits evidences of right lateral movement, while in the latter, the movement is left lateral. Neotectonic activity is evident in both these faults.

Sargodha- Lahore-Delhi ridge

the most charactreistic feature of this sheet is the subsurface Sargodha- Lahore-Delhi ridge with N-S trend in areas around Sriganga Nagar and beyond Sutlej it veers towards northwest to plunge below salt Range.This ridge is clearly depicted by the basement depth contour. Around Chiniot the crystalline basement is located at a depth of around 400 m, while east of Firozpur its depth is around 700 m (Zira-1, ONGC well). This basement high separates the Punjab foredeep basin in the northeast from the peripheral foreland Bikaner-Nagaur basin in the southwest.

From limited data,it is found that a gravity high is present around Sriganga Nagar. The gravity value decreases towards northeast.

SEISAT SHEET 05 Himachal Himalaya and adjoining Indogangetic plains

Important physiographic features

Parts of the states of Himachal Pradesh, Haryana, Jammu and Kashmir, Punjab, Uttar Pradesh and a small portion of Pakistan. Some of the important localities are Ambala, Chamba, Chandigarh, Dharamshala, Kathua, Keylong, Gurdaspur, Hisar, Saharanpur, and Shimla. Major rivers, descending from the snow clad Great Himalaya and debouching into the vast alluvial plains, are Beas, Chandra, Ravi, Sutlej and Yamuna.

TECTONICS

Broadly, the area can be subdivided into two distinct domains. Towards northeast rock sequence of the Himalayan Orogenic Belt is exposed, While the remaining area is covered by the Quaternary alluvial deposits of the Indo-Gangetic Plains.

The litho-tectonic packets of the Himalayan Orogenic Belt are poorly metamorphosed litho-unit (F) C of the Tethyan sequence, high (F) F and low (F) FC grade assemblages of the central and other crystallines and lesser Himalayan Belt, respectively along with granitoids and basic volcanics. The southern fringe of the Himalyan belt is occupied by cover is represented by alluvial fill along the foredeep (cf) and pericratonic fills on attenuated continental crust (cpr) on northern and southern sides respectively of the Delhi-Sargodha Ridge.

Main Central Thrust

Within the Himalyan Belt, the northernmost conspicuous structural element is the Main Central Thrust (MCT). From Manali towards east throughout the entire Himalaya almost upto the eastern syntaxis, this is considered as one of the most important tectonic surfaces. However, northwest of Manali it is not clearly discernible.

Vaikrita Thrust

Further south within the Lesser Himalayan package the other important tectonic surface is the Vaikrita Thrust (VT). This Lesser Himalayan belt is separated from the Frontal belt (comprising the Siwalik sequence) by the Main Boundary Thrust (MBT). The southern limit of the Frontal Belt is marked by the Main Frontal Thrust (MFT) which has its surface manifestations only at a few places.Within **MBT and MFT** the belt is traversed by several subsidiary thrusts some of which have considerable spatial extent viz. **Jwalamukhi** thrust and **Drang** Thrust. Evidences of neotectonic activity have been documented at several places along MBT and in western parts of Jwalamukhi Thrust. The Frontal Belt package is affected by several regional scale folds, of which **Mastgarh** and **Paror** anticlinal axial trances are mappable for considerable distance.

In addition to the structural discontinuities sub-parallel to the Himalayan trend, there are a number of faults/lineaments transverse to this fold-thrust belt. The **Sundernagar** Fault (also known as Manali Fault) is a dextral transverse structure which extends from Higher Himalayan to the Frontal Belt. This fault is considered to have caused the swing of the Frontal Belt from NW-SE to N-S .The **Ropar** Fault, occurring northwest of Chandigarh is postulated to be the continuation of the Sundernagar Fault. A fault with similar trend and sense of movement is identified in the southeastern side of Chandigarh. Further east, the **Yamuna** Tear displays sinistral sense of movement. All these faults exhibit neotectonic activity. In the southeastern part, the **Mehendragarh-Dehradun** Fault is a sub –surface structure.

SEISAT SHEET 06 Himachal, Kumaon-Garhwal Himalaya and their environs

The area mainly represents the Himalayan tract of the Kumaon-Garhwal region, parts of west Nepal, Himachal Pradesh and Ladhak. While the northeastern part is occupied by the Tibetan Plateau, the southwestern sector is the Indo –Gangetic plains. Some important localities include Almora, Dehradun, Nanital, Pithoragarh and Uttarkashi in the Himalaya, Bijnor and Haridwar in the plains and Gartok in the Tibetan Plateau. The major rivers draining the area are Kali, Ganga, Ramganga Sutlej and Yamuna

Tectonics

Trans-Himalayan Tectogen

The northeastern part exposes rocks of the Trans-Himalayan tectogen along with late to post tectonic granitoid and ophiolite bodies. South of this, the belt between the Karakoram Fault and the Indus Suture Zone is occupied by cover rocks, affected by Himalayan orogeny F(C), late to post tectonic granitoid, ophiolite and litho-packets of the accretionary complex.

Main Himalayan Belt

Further south, within the main Himalayan belt, the tectonic packages are Tethyan and Lesser Himalayan cover sequences affected by Himalayan orogeny F(C), low and high grade complexes tectonically reworked during Himalyan orogeny (F)FC and (F)F, respectively. The foothill belt constitutes foredeep sediments affected by the terminal phase of the Himalyan orogeny (F). south of foothills the tract is covered by the alluvial p (cf).fill of the Gangetic foredeep

SEISAT SHEET 09 North Delhi Fold belt and part of Vindhyan Basin

Important physiographic features

The sheet comprises parts of eastern and northeastern Rajasthan along with small portions of Haryana, Madhya Pradesh and Uttar Pradesh. Major rivers are Banas, Chambal and Yamuna.Well known localities are Alwar, Bharatpur, Delhi, Jaipur, Mathura and Shivpuri.

Tectonics

Litho-packets of different tectonic domains, ranging in age from Archaean to Cenozoic are exposed in this area. In the west, the basement element is dominantly represented by vast expanse of unclassified gneisses (B)GN of Manglawar Complex with lenticular patches of high grade gneiss/granulite (B)H of Sandmata Complex and a small portion of composite batholithic complex (b)y of the Berach Granite. This is followed towards southeast by the greenstone belt (B)GS of Hindoli.

In the southeastern corner, the Bundelkhand Granite constitutes the basement. The Proterozoic fold belt (F)is mainly represented by the Delhi Group. Deccan basalt crops out in the southeastern part. Cover sequence of different tectonic milieu are present in this area. Vindhyan is considered as Proterozoic shelf facies cover, developed in intracratonic sag (C)IS, while the Cenozoic covers are formed as pericratonic fill on attenuated continental crust (cpr), in intracratonic linears (cl) and as alluvial fill along foredeep (cf). Amongst these, the former covers a huge tract in the northern part as well along the Chambal River course.

On the other hand the latter two are present only in the southeastern corner. Besides these, Gwalior Group, representing volcano-sedimentary pile in intracratonic abortive rift (FC) IR, is present in the southeastern corner. the NE-SW trend of the Delhi fold belt defines the main structral grain of this area. Several fauults/lineaments traverse along this trend. Amongest these, the most conspicuous one is the Great Boundary Fault. Surface trace of this fault is delineated as a well defined lineament (Chittaurgarh-Machilpur Lineament) because of the presence of contrasting geomorphic units on either side. Around Bundi the fault marks the northern marginof the Vindhyan basin but towards northeast it becomes intrabasinal and basin margin is marked by a separate fault. The Chambal-Jamnagar Lineament, occuring south of the great Boundary Fault, is the trace of another sub-parallel fault which has developed near this northern margin. These faults/lineaments together represent a system, developed along the northern margin of the Vindhyan basin. The Great Boundary Fault along with its subsidiaries exhibit imprints of repeated reactivation at different atages of evolutionary history of this belt.

The migration of Chambal and Yamuna river course have resulted from themovement along this fault system. North of Jaipur, several NE-SW trending neotectonic faults form a series of horst and graben structures. The Mahendragarh-Dehradun Fault extends towards northeast upto the Himalyan foothills. The central part of the approximately N-S trending neotectonic faults. These faults cut across the Delhi as well Mangalwar rocks and extend within the alluvial covered tract. Prominent lineament in the region display three distinct trends viz. A-NE-SW, B-NW-SE and C-N-S

SEISAT SHEET 10 Indo Gangetic plains of Uttar Pradesh and uplands of Madhya Pradesh

Important physiographic features

The sheet comprises the Flanked in the northeastern corner by the foothill belt of Nepal Himalyan and towards south by the uplands of Madhya Pradesh and vast alluvial tracts of Uttar Pradesh. The important localities are Agra, Bareilly, Banda, Kanpur, Lucknow and Moradabad in Uttar Pradesh and Bhind and Gwalior in Madhya Pradesh. The major rivers draining the area are Chambal, Ganga, Sharda and Yamuna

Tectonic

Major part of the area is coverd by alluvial fill of the foredeep (cf) and pericratonic fill on attenuated continental crust (cpr). The foothill belt exposes poorly/unmetamorphosed litho-assemblage folded during Himayan Orogeny (F)C and rocks of the frontal belt affected by the terminal phase of the Himayana Orogeny (F). the southern part exposes composite batholithic complex (B)y, isolated patches of gently folded volcano- sedimentary piles in aborative rift (FC)IR and shelf facies cover in intracratonic sag (C)IS. Conspicuous structural elements are Great Boundary Fault (GBF), Moradabad Fault (MF) and Lucknow Fault (LF). The NE-SW trending GBF displays a left lateral sense of movement. The MF has a E-W trend in the western part, which takes an ENE-WSW swing towards east. This fault is considered to be seismogenic. The LF exhibits a NNE-SSW trend. North of Shahjahanpur another WNW-ESE trending sub-surface fault is present which has a considerable down throw towards north. Amongst several sets of lineaments, many are transverse to the Himalyan trend, while a few are sub parallel to it. The Main Boundary Thrust is present in the northeastern corner of the area.

In general, the basement depth increases from south to north (1000m to 6000m). The overall trend of the basement contours is sub-parallel to the Himalaya. However, some digitation of contours, depicting basement irregularities are common. Around Sitapur the contours reflect a basement elevation which is followed towards north by a depression (Sarda Depression) north of Shahjahanpur. These two corresponding basement undulations are separated by a WNW - ESE trending fault with down throw towards north which might have accentuated the northern depression. In the vicinity of the GBF and MF

SEISAT SHEET 11 Nepal Himalaya and Adjoining Indo-Gangetic Plains

Important physiographic features

The northern part of the sheet comprises the Nepal Himalaya and its Tarai region. Towards south, it is followed by the vast alluvial tracts of Uttar Pradesh whose southern fringe is marked by rocky uplands. The important localities are Mari, Nepalganj and Satbaria in Nepal and Allahabad, Bahraich, Faizabad, Gorakhpur, Mirzapur and Varanasi in Uttar Pradesh. Major rivers are Ganga, Ghaghara and Yamuna.

TECTONICS

Main Boundary Thrust

The tectonic packet, occupying the higher Himalaya, is represented by poorly metamorphosed sequence (Tethyan) folded during the Himalayan Orogeny (F)C. Litho-packets of comparable status are also present within the Lesser Himalayan belt, particularly north of the Main Boundary Thrust (MBT). The Tethyan sequence is successively followed to the south by the high grade complex of the Central Crystalline (F)F, and low grade complexes (F)FC reworked during the Himalayan Orogeny.

North Almora Thrust (NAT) and South Almora Thrust (SAT)

The Almora Crystalline, a high grade complex similar to the Central Crystalline, occupies the tract between the North Almora Thrust (NAT) and South Almora Thrust (SAT). Pre to syntectonic granitoids and basic volcanics are found to have been emplaced within the fold-thrust belt. The foothill Himalaya south of the MBT, exposes cover rocks of the foredeep (Siwalik) affected by the terminal phase of the Himalayan Orogeny (F). South of the Himalyan belt the vast tract of the Indo-Gangetic plain is occupied by Quaternary alluvial fill along foredeep (cf) and pericratonic fill on attenuated continental crust (cpr). Along the southern fringe of the area the shelf facies cover sequence in intracratonic sag (Vindhyan) is present (C)IS

Main Central Thrust (MCT)

Three prominent thrusts are present within the main Himalayan belt. Among these, the northernmost is the Main Central Thrust (MCT)which separates the high grade Central Crystallines from the low grade Lesser-Himalayan packages.

Towards south the NAT and the SAT delimit the northern and southern boundaries respectively of the high grade litho-packages of the Almora Crystalline.

Further south the main Himalayan sequence is tectonically translated over the foothill Siwalik belt along the MBT which displays contemporary tectonism in certain sectors. Towards east, along the southern boundary of the Siwalik, the development of MFT is recorded. Besides these thrusts, within the main Himalayan belt a N-S trending fault bound graben, designated as **Takhola** Graben, is present in the northeastern corner of the sheet. From the Indo-Gangetic plains several sub-surface faults are postulated. These sub-surface faults exhibit three prominent trends, viz. (i) NNE-SSW to NE-SW ii) NNW-SSE to NW-SE and (iii) E-W. Out of these, the E-W trending fault set in Azamgarh - Gorakhpur area defines the **Mirganj** Graben.

Geological section across this graben from Ghazipur to Gorakhpur is presented in Figure-1. The northern part of the graben is very steeply down faulted. This is clearly depicted by the basement contours which indicate that towards north the basement reaches a depth of about 8000 m and towards south the same is only around 2000m. Several lineaments are present in the Indo-Gangetic plains, which exhibit two dominant trends, viz.

(i) NNW- SSE to NW- SE

(ii) NE- SW to ENE- WSW.

The general configuration of the Bouguer Gravity Anomaly contour is WNW-ESE, parallel to the Himalayan trend. In the southwestern corner the value is —20 m Gal which gradually changes to —200 m Gal towards north, indicating an increase in thickness of the cover sequence towards the Himalayan foothills.

Distinct swing of the contours can be observed east of Allahabad and Bahraich. At the former location the swing appears to be in accordance with the ENE-WSW trending lineaments, probably representing horst/graben structures, while in the latter location the swing might be depicting variation in thickness of the cover sequence, resulted from broad undulation of the basement (low).

SEISAT SHEET 12 Eastern Nepal Himalaya and Indo-Gangetic plains of Bihar

Important physiographic features

Two of the most damaging earthquakes in India have occurred within this area. These are the Bihar-Nepal earthquake of 1934 and 1988. The area that were worst affected by these two earthquakes are in north Bihar which comprise the southern part of this sheet; the middle and northern segments include eastern Nepal and parts of Tibet respectively. Well known localities are Chhapra, Muzaffarpur and Patna in Bihar; Dolakha, Katmandu, and Kunchha in Nepal and Keyrong Dzong in Tibet. Major drainage in the plains are represented by Ganga, Gandak and Ghaghara rivers and in Himalaya by Narayani River.

TECTONICS

Litho-tectonically the area can broadly be divided into three major belts. The Indo-Gangetic plains intervene between the peneplained surfaces of the Peninsular Shield in the south and

Extra-Peninsular belt to the north. The Peninsular Shield element is represented by isolated patches of gently folded sedimentary piles (FC) IR along the southern tip of the area.

The Indo-Gangetic tract is covered by alluvial fill along foredeep (cf). The Extra Peninsular belt is mainly occupied from north to south by poorly matamorphosed sequence (Tethyan) folded during the Himalayan Orogeny (F)C, the high grade complex of the Central Crystallines and low grade complexes of the Lesser Himalaya tectonically reworked during the Himalayan Orogeny [(F)F and (F)FC respectively]. Besides, pre to post tectonic granitoids are also recorded. The foothills Himalaya, south of the Main Boundary Thrust(MBT) exposes cover sequence of the frontal belt (Siwalik) affected by the terminal phase of Himalayan Orogeny (F).

Main Central Thrust and Main Boundary Thrust

The two main structural discontinuities within the Himalaya are Main Central Thrust (MCT) and the Main Boundary Thrust (MBT). The MCT separates the high grade Central Crystallines from the lower grade Lesser Himalayan packets. Further south allochthonus/para-autochthonus packets of the Lesser Himalaya were translated over the Siwalik belt along the MBT.

Main Frontal Thrust

Towards west, along the southern margin of the Siwalik, the development of the MainFrontal Thrust (MFT) is recorded. Both the MBT and the MFT are active in certain segments.

Judi Fault

In the western part the northeasterly trending Judi Fault cuts across the whole Himalayan package. Along the southern extension of this fault evidences of neotectonism are observed. Normal faults defining the **Kung Co Graben** in the east and **Takhola** Graben in the west are present within the Tethyan belt. In the Kung Co Graben, the fault in the eastern side is well exposed and can be traced for a considerable distance. In contrast, on the western side, discontinuous conjugate normal faults offset Quaternary sediments. Along the eastern fault total throw is found to be 1600m

The West Patna Fault (WPF), East Patna Fault (EPF) and Munger Saharsa Ridge Fault (MSRF)

Out of several NE-SW trending lineaments, **Gaurishankar** and **Everest** lineaments extend from the Indo-Gangetic plain to well within the Himalayan belt. The sub-surface configuration of the foredeep plain is architectured by some major faults, defining horst-graben structures. These faults display northeasterly and northwesterly trends. The West Patna Fault (WPF), East Patna

Fault (EPF) and Munger Saharsa Ridge Fault (MSRF), having northeasterly trend, form alternate horst and graben from west to east respectively. South of Shikarpur, another conspicuous basement configuration is represented by Gandak Depression.) vast of this depression lies the Sitamari **High** which is a wedge shaped horst, bound by northeasterly and northwesterly trending faults.

These tectonic discontinuities of the foredeep, particularly having a northeasterly trend, are considered to be the locale of post collisional strain adjustment near the leading edge of the Indian Shield and thus are likely to be neotectonic. This is evident from the collinearity between **EPF** and the epicenters of Bihar-Nepal earthquakes of 1934 and 1988 as well the alignment of hot springs parallel to this trend.

Basement contours broadly reflect the E-W trending and northerly dipping configuration of the basement below the Gangetic plain. However, they display complex digitations in the vicinity of major subsurface faults. In the terrain between WPF and MSRF these contours exhibit NE-SW trending curvatures in conformity with the trend of these faults. These curvatures gradually flatten towards south, probably pointing towards a decrease of throw of the faults. In the Gandak Depression basement contours have a southeasterly curvature which again corresponds to the NW-SE trend of the adjoining faults. Bouguer Gravity Anomaly data bring out corroborative basement configuration. These anomalies reflect an increase in the thickness of the cover sediments towards the Himalayan foothills. Over the Gandak Depression the gravity contours have a smooth trend; while towards east these contours display complicated digitations. These patterns probably reflect unevenness of the cover thickness, resulted from the highly faulted domain of the basement as well the deep seated nature of these faults compared to the faults of the Gandak Depression.

CONCLUSION

A review of the historical as well as instrumental earthquake activity in North western Himalaya region indicates that different parts of the region are characterized by a moderate to very high level of seismic activity. It was observed that large and damaging earthquakes have occurred in the region. This large region includes the Great Kangra earthquake of 1905 in the west and the Great Bihar Nepal earthquake of 1934 in the east.Based on the observed seismicity ofNorth western Himalaya region (longitudes 73° – 84° E; and latitudes 25° – 36°N) from 1833 to 1998, the following conclusions have been derived:

1. Western Himalayan Syntaxis between Kohistan Arc and Potwar Plateau: maximum clustering of seismic events is within the Kohistan Arc, considered to be part of the Indus-Kohistan Seismic Zone. Deep focus (>150 km) seismic events are comparatively more prevalent north of the MKT.
2. Tibetan Plateau and Kashmir Ladakh Himalaya: The maximum concentration of seismic events is in the southwestern corner between MCT and MBT where earthquakes are dominantly shallow focus (<40 km).
3. North Rajasthan and Punjab Sector:Seisamicity is mainly concentrated in two domains. One is in the Himalayan foothill region, particularly around Salt Range Thrust and Kallar Kabar Fault. The other is in and around the vicinity of Sargotha-Lahore-Delhi Range.
4. Himachal Himalaya and adjoining Indo Gangetic plains: Seismic activity is mainly concentrated along the Himalyan Belt particularly in the northwestern sector around Chamba
5. Himachal, Kumaon -Garhwal Himalaya & their Environ: Seismically this area constitutes one of the most active domains of the Himalaya. Within a period of 181 years from 1816 to 1997, a total of 297 seismic events occurred in this region.
6. Eastern Nepal Himalaya and Indo-Gangetic plains of Bihar: The most devastating earthquakes of 1934 and 1988 had epicenters within this region.

Based on this study the following results were obtained:

1. Compiled a consolidated catalogue of this region
2. Compiled statistics of this data
3. Compiled isoseismal mapsand fault plan solution

After working on 10 SEISAT sheets, and compiling the seismicity and tectonic data, several advantages and limitations of working on this kind of data were observed.These are listed below.

Advantage of studying SEISAT data

1. Description of physiographic features available for the entire study area
2. Seismicity data was available in tabular form
3. Beach ball given for several events, which helps in understanding the fault mechanism
4. Tectonic data was available on map
5. Overlay of seismicity and tectonics helps in correlating/ better understanding of seismotectonics

Limitations of data

1. Catalogue of historical earthquakes in each sheet is for large magnitude destructive earthquakes. However, the smaller earthquakes are considered in the frequency distribution table. Therefore, the number of earthquakes in the two tables is not consistent, listed earthquakes are fewer than those shown in map.
2. In SEISAT sheet time frame is not mentioned. It creates confusion whether data is in IST or in UTC or some other time frame. For the Uttarkashi earthquake,given in SEISAT 06, in isoseismal map the date given is 20/10/1991 but in Table 1 it is 19/10/1991.
3. Sometimes magnitude scale is not mentioned.
4. Frequency magnitude distribution table is not available for SEISAT Sheets 04, 09, 10 & 12.
5. For Isoseismal maps the following deficiencies were observed
    a. Magnitude is not mentioned for historical earthquakes
    b. Intensity Scale, latitude and longitude not given in several sheets,
    c. Several intensity scales used, e.g. Milne scale, RF, MM, MSK, Mallet scale
    d. Isoseismal map of Bhind earthquake (1994) available but latitude and longitude not given.
    e. Isoseismal map of Delhi earthquake (1960) available but latitude and longitude not given

Applications

This data, with more inputs, will prove useful for managing and mitigating seismic hazards.

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