

## The 24th March, 1995 Chamba Earthquake (NW Himalaya), Field Observations and Seismotectonics

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**Abstract:** On 24th March, 1995 at 17:22 hr. IST (11:52 UTC) an earthquake of magnitude 4.9 mb (USGS) struck the Chamba region in northwest Himalaya. The epicentral zone lies 8-10 km northeast of Chamba township. Based on the isoseist characteristics, the source mechanism of this earthquake has been evaluated. The longest axis of the isoseismal is aligned in NW-SE direction, which is parallel to the trend of strike of rocks in the area. The pattern of isoseismals suggest that the causative fault for the 1995 Chamba earthquake is parallel to the local Himalayan trends and the strain has been released at a very shallow depth.

**Keywords:** Seismology, Earthquake, Chamba, Himalaya

### INTRODUCTION

The Kangra-Chamba region is a part of the active seismic belt of the Himalaya. The area has experienced a great earthquake on 4th April, 1905 which caused major damage in Bharmaur area (Middlemiss, 1910). The other damaging earthquakes of the Chamba region include that of 1945, 1947 and 1950 of magnitude 6.5, 6.0 and 5.5, respectively and of Dharamsala region are 1968, 1978 and 1986 of magnitude 5.4, 5.0 and 5.7, respectively.

On 24th March, 1995 a moderate earthquake of magnitude 4.9 mb (USGS) shook the Chamba region and its surroundings at 17:22 hrs. IST. The earthquake was felt strongly in Chamba town and further southeast. To the northeast of Chamba it was felt up to Bharmaur, in the northwest up to Tisa and in the southwest it was felt up to Dalhousie and Pathankot. Tremors that lasted for a few seconds caused low damage in a zone of about 8 km radius, maximum damage being in Pilure-Baraur sector located 8-10 km northeast of Chamba town. The author visited the affected region two days after the main shock in order to study the pattern of land fissures and cracks developed in the region and to assess the extent of damage.

### EPICENTRAL PARAMETERS

The epicentral parameters given by USGS and IMD are as follows:

	USGS	IMD
O-Time	11:52:39.95 (UTC)	17:22:05 (IST)
Latitude	32.564 N	33.2 N
Longitude	75.999 E	76.06 E
Depth	33.00 km (Normal)	Shallow
Magnitude	4.9 mb	4.5

### GEOLOGICAL SETTING

Lithologically the Chamba region is characterised by rocks of Chamba succession (Rattan, 1973) comprising of Chamba Formation, Pukhri Formation, Manjir conglomerates, Salooni Formation, basic metavolcanics and Kallhel Formation. The Chamba Formation consists of slates, phyllites, schistose quartzites, quartzites and schists. This formation in the north is overlain by Pukhri slates. The Manjir conglomerates consists of thick sequence of conglomerate, slate, quartzite, limestone and mudstones. The Salooni Formation unconformably overlies the Manjir Formation and comprises of slates. The amygdaloidal and bedded lava flows of basaltic to andesitic composition and limestone form the upper part of the Chamba succession. The whole Chamba succession is underlain by huge



seismicity in the NW Himalaya is confined to 10-20 km and thus refers to very shallow activity (Molnar, 1990; Ni and Barazangi, 1984 and Mahajan, 1991).

Table 1 shows the list of earthquakes which have occurred in the Kangra-Chamba region since 1900. The 1947 Chamba earthquake had been studied by Kapila (1959) who assigned epicentral intensity of X (MM scale) to the event. The isoseismals drawn by Kapila (1959) show N-S orientation of the causative fault which was explained later by Krishnaswamy (1962) as a possible N-S trending tear fault in the area. Chandra (1978) correlated 1947 Chamba earthquake with the Panjal Thrust lying south of the Chamba valley. Das Gupta et al. (1982) studied the fault plane solution of 11th December, 1975 earthquake and suggested thrust faulting along NW-SE trending tectonic plane.

**FIELD OBSERVATIONS**

A systematic study was carried out to infer the possible trend of causative fault. During the survey land fissures (tension gashes) and the pattern of damage were studied. Tension gashes

were seen on the headward side of the slope towards the Sal river in the valley. The author has used MSK-64 intensity scale for studying the damage to different types of structures in the Chamba region specifying type of vulnerability of the buildings, type of structures and grade of damage. According to MSK-64 scale three classes of vulnerability have been proposed (A to C) representing the strength of a typical "adobe house, brick building, and reinforced concrete (RC) structure respectively." The damage grade represents a linear increase in the strength of shaking with slight damage in Grade-1 to a total damage in Grade-5.

District Hospital (New Building) made up of RCC structure developed wide cracks in the walls indicating damage of Grade 2. The walls made up of burnt brick masonry showed diagonal cracks of 1-2 cm width and opening up of joints. In the CMO's residence, the damage was caused along the corners of the walls which opened up to a width of 2-3 cm and showed opening on both sides of the wall made up of burnt bricks. The bricks of the upper half portion of the walls show movement and tilt towards north at an angle of 20-30 degrees.

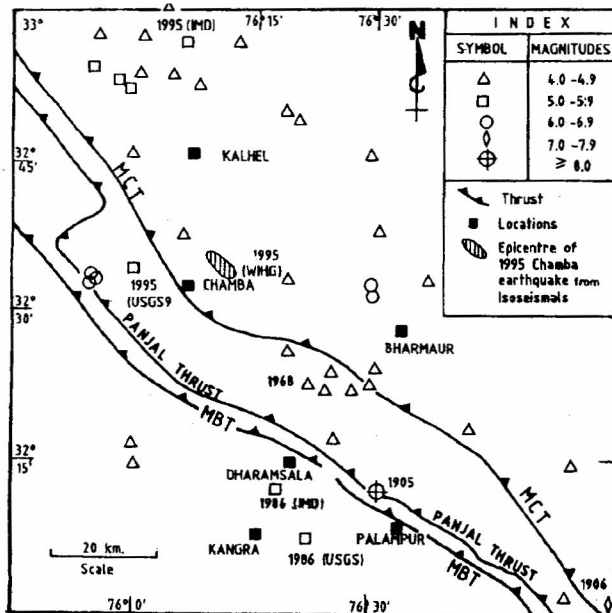


Fig.2. Seismotectonic map of Kangra-Chamba region. The seismicity data from 1900-1995.

**Table 1.** List of Earthquakes of magnitude 4 and above occurred in the Kangra-Chamba region.

S. No.	Date	Location		Magnitude	Depth	Ref.
		Lat. N	Lon. E			
1	04/04/1905	32.30	76.50	8.0	25	ISS
2	28/02/1906	32.00	77.00	7.0	-	ISS
3	22/06/1945	32.60	75.90	6.5	60	ISS
4	10/07/1947	32.60	75.90	6.0	60	ISS
5	12/08/1950	32.60	75.90	5.5	-	ISS
6	25/09/1950	32.60	75.90	-	-	ISS
7	20/09/1951	32.60	76.50	6.4	-	ISS
8	21/02/1965	32.24	76.90	4.5	33	PDE
9	20/09/1967	32.60	76.10	-	59	PDE
10	05/11/1968	32.37	76.37	4.9	33	PDE
11	05/11/1968	32.37	76.56	-	33	PDE
12	23/01/1969	32.24	76.06	4.0	33	PDE
13	23/01/1969	32.16	76.03	-	33	PDE
14	05/03/1970	32.42	76.49	4.9	33	PDE
15	29/01/1972	32.85	75.95	4.7	58	PDE
16	16/12/1973	32.28	76.02	4.9	90	PDE
17	16/11/1974	32.84	76.13	4.8	63	PDE
18	30/10/1975	32.90	76.90	5.2	34	PDE
19	11/12/1975	32.84	75.98	5.1	59	PDE
20	16/09/1975	32.37	76.45	4.6	44	PDE
21	16/11/1975	32.60	76.50	-	96	PDE
22	10/12/1975	32.82	76.19	5.0	33	PDE
23	07/01/1976	32.85	76.96	5.4	50	PDE
24	09/01/1976	32.95	76.02	4.7	22	PDE
25	10/04/1976	32.72	76.51	4.5	50	PDE
26	16/04/1976	32.07	76.01	4.0	92	PDE
27	19/01/1979	32.38	76.48	4.1	05	PDE
28	26/11/1980	32.48	76.40	4.0	09	PDE
29	04/09/1980	32.02	76.90	4.0	15	IMD
30	14/02/1981	32.59	76.63	4.0	2.5	ISS
31	12/07/1981	32.73	76.00	4.5	50	PDE
32	07/05/1982	32.94	76.23	4.5	2.8	ISS
33	18/05/1982	32.42	76.40	4.0	15	ISS
34	13/04/1983	32.78	76.24	4.0	08	ISS
35	23/05/1984	32.94	76.91	4.8	58	PDE
36	29/12/1985	32.62	76.10	4.9	33	PDE
37	26/04/1986	32.12	76.37	5.5	33	PDE
38	26/12/1987	32.12	76.69	4.3	33	PDE
39	23/06/1991	32.30	76.71	4.6	33	PDE
40	06/01/1992	32.28	76.41	4.5	33	PDE
41	13/02/1992	32.63	76.51	4.6	33	PDE
42	06/09/1992	32.43	76.33	4.6	33	PDE
43	13/05/1994	32.56	76.50	4.0	33	PDE
44	09/11/1994	32.79	76.33	4.4	12	PDE
45	19/01/1995	32.55	76.33	4.2	10	PDE
46	24/03/1995	32.56	75.99	4.9	33	EDR

ISS= International Seismological Summary; PDE =Preliminary Determination of Earthquakes; IMD = Indian Meteorological Department; EDR = Earth quake Data Report.

The damage to this building is of Grade 3. The wall hangings swung to one direction. Also, ceiling got separated from the walls.

On the edge of the terrace on the bank of Ravi river, a few houses situated on loose soil developed cracks of Grade 2 in the ground floor and of Grade 3 in the first floor. The poorly constructed buildings (5%) suffered damage of Grade 4.

The Garur (God) pillar erected outside the famous Laxmi Narain temple of Chamba town showed a movement of upper part of the pillar by 2-3 cm in the NE direction. The small bells rang in the temple. The newly built Bhuri Singh

museum in the town suffered damage in the form of fine cracks in the walls of ground floor and first floor. In the Chamba town 90% of the people reported hearing zooming sound before the earthquake followed by strong jerk. The people also reported horizontal movement.

At village Ludrera along the Sahoo road, about 10% houses located on the right bank of river Sal on hard rocks suffered damage of Grade 3 in adobe houses. 90% houses located away from river Sal at village Sungal suffered damage of Grade 2. At village Baraur the damage grade to Type 'B' buildings was of Grade 3 and in Type 'C' buildings it was of

Grade 2. The adobe houses suffered damage of Grade 4 in 25% of houses and Grade 3 damage in 70% houses. A total of 5% houses of Type 'A' had suffered damage of Grade 5. The school building of primary section suffered damage of Grade 4. The Veterinary hospital building suffered damage of Grade 3 especially the gable portion. At Baraur, house of Mr. Piyar Singh showed movement of slate roof in N 270° direction. In the Chambhi village large gaps were seen along joints of the walls which were tilted in ESE direction. The ground surface developed cracks of 3-4 cm width trending east-west direction.

Along the Jadera road in the Chambhi village the walls in the ground floor suffered damage of Grade 3. The new building of Mr. Dev of the same village developed wide cracks. The separated portion was pushed towards ESE direction. At village Garjan, the pillar of an IPH water tank showed damage of Grade 1. Most of the people of Chambhi, Baraur and Pilure area reported blast like sound before the earthquake. Similar type of damage was noticed in Koni-Kl-Behi, Saron, Lola, Garoli and Kaila villages. In Mugua and Jadera villages the intensity of damage fell significantly. Similar damage was reported from village Randoh by local residents.

Most of the inhabitants of Maredi, Jamhar, Puneta and Andraru villages heard a blast with cracking sound. In these villages the Type 'C' buildings suffered damage of Grade 1. However, many houses of Type 'A' structures suffered damage of Grade 2 with few houses showing damage Grade 3 and 4. At Chimnu village 50% Type 'A' houses suffered Grade 3 damage. At Pilure village Grade 4 and Grade 5 damage was seen in few buildings of Type 'A' structures. The Type 'B' buildings suffered damage of Grade 2 and 3. At the same village the driver of HRTC bus coming from Sahoo towards Chamba reported vibration during an earthquake followed by shaking in horizontal direction. The earthquake lasted 10-15 seconds as reported by local residents of the area.

Along the Chamba-Tisa road (Fig.1) at village Saror, most of the Type 'C' building showed damage of Grade 1 with cracks in the walls and opening up of joints. Many Type 'B'

buildings suffered Grade 2 damage. The Haripur, Rajpur and Kiyani villages fell under the same intensity zone VI but the damage decreased beyond Kiyani. The village Rajnagar falls under intensity zone V.

Southeast of Chamba towards Bharmaur road, damage was observed up to village Jangi. Further east, observations recorded loss of balance and falling of some unstable objects (like boulders) at a number of places. The Mahla, Karian, Kuran and Jangi villages located on Chamba-Bharmaur road suffered Grade 1 and 2 damage in most of the Type 'B' and Type 'A' houses, respectively. Very few Type 'C' houses showed minor cracks. Beyond village Dabra the damage grade decreases and only finer cracks were seen in the Type 'A' and Type 'B' houses at village Rakh.

*Land Fissures:* In the meizoseismal zone, land fissures were observed at village Pilure running in the east-west direction which could be traced up to 400-500 metres. The fissures were seen on the soil cover which was about 1 meter thick over Manjir conglomerates dipping in opposite direction of the slope of the fields.

*Isoseismals:* Based on the damage survey of 24th March, 1995 Chamba earthquake, a isoseismal map has been prepared. The

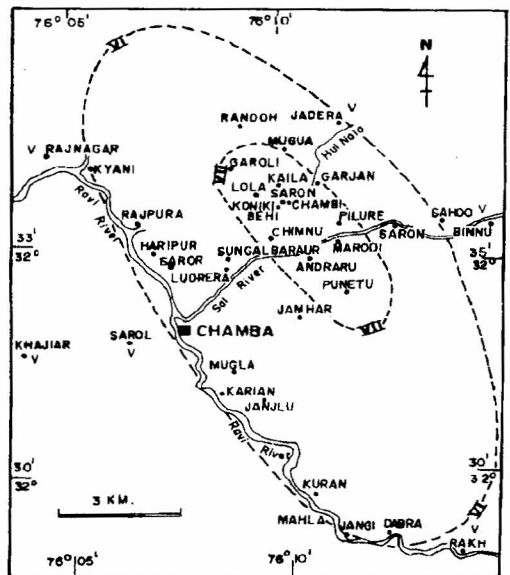


Fig.3. Isoseismal map of 24th March, 1995 Chamba Earthquake (Himachal Pradesh).

maximum intensity isoseismal VII surround the villages of Pilure, Baraur, Chambi and some neighbouring small villages covering approximately 4 x 10 km area with its long axis in NW-SE direction and minor axis in NE-SW direction (Fig.3). The isoseismal VI covers an area of 11 x 26 km. The damage survey shows fast attenuation pattern towards the northeast side and slow pattern in the southwest direction.

### CONCLUSION

The Chamba earthquake was a shallow focus event of moderate magnitude affecting the Chamba region and its surroundings. The epicentre of the earthquake having an intensity of VII on MSK-64 scale lay near village Pilure.

The isoseismal exhibits elliptical shape whose major and minor axes run in NW-SE and NE-SW directions, respectively. The intensity VII covers approximately 4 x 10 km<sup>2</sup> area. The major axis of the isoseismal follows the regional Himalayan trend. Based on the above studies it can be proposed that the 24th March, 1995 Chamba earthquake was caused due to slip along the NW-SE trending tectonic features.

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### References

- CHANDRA, U. (1978). Seismicity, earthquake mechanism and tectonics along the Himalayan mountain ranges and vicinity. *Phy. Earth Planet. Inter.*, v.16, pp.109-131.
- DAS GUPTA, A., SRIVASTAVA, H.N. and BASU MALIK, S. (1982). Source mechanism of earthquakes in Kangra-Chamba region of Himachal Pradesh, India. *Bull. Ind. Sec. Earth Tech.*, v.19, pp.102-116.
- KAPILA, I.P. (1959). A seismic design of Bhakra Dam project. *Proc. 1st Symp. Earthquake Engg., Roorkee.*
- KRISHNASWAMY, N.S. (1962). Probable correlation of the structures and tectonic features of the Punjab, Himachal tertiary re-entrant with pattern of seismicity of the region. *Proc. 2nd Symp. Earthquake Engg., Roorkee.*
- KUMAR, S. and MAHAJAN, A.K. (1991). Dharamsala seismotectonic zone neotectonics and state of stress in the area. *Jour. Him. Geol.*, v.2(1), pp.53-59.
- MAHAJAN, A.K. (1991). Seismotectonic activity of Dharamsala-Palampur area in relation to neotectonics. Ph.D. thesis, Punjab University, Chandigarh.
- MIDDLEMISS, C.S. (1910). The Kangra earthquake of 4th April, 1905. *Mem. Geol. Surv. India*, v.26, 302p.
- MOLNAR, P. (1990). A review of the seismicity and the rates of active underthrusting and deformation at the Himalaya. *Jour. Him. Geol.*, v.1(2), pp.131-154.
- NI, J. and BARAZANGI, M. (1984). Seismotectonics of the Himalayan collision zone: Geometry of the underthrusting Indian plate beneath the Himalaya. *Jour. Geophy. Res.*, v.89, pp.1147-1163.
- RATTAN, S.S. (1973). Stratigraphy and sedimentation of the Chamba area, western Himachal Pradesh. *Him. Geol.*, v.3, pp.231-248.
- SINGH, K. (1993). Reverse and oblique slip movement along the Chamba Thrust, Northwest Himalaya: Implications for tectonic evolution. *Jour. Him. Geol.*, v.4(2), pp.143-148.
- SRIVASTAVA, H.N., DUBE, R.K. and HANS RAJ (1987). Space and time variation in the seismicity patterns preceding two earthquakes in the Himachal Pradesh, India. *Tectonophysics*, v.138, pp.69-77.
- THAKUR, V.C. (1992). *Geology of western Himalaya*, Pergamon press, London, 362p.
- VIRDI, N.S. (1979). Status of the Chail Formation vis-a-vis Jutogh-Chail relationship in the Himachal Lesser Himalaya. *Him. Geol.*, v.9(1), pp.111-125.

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