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Seismology in India – An Overview

SEISMOTECTONICS INFERRED FROM EARTHQUAKES AND EARTHQUAKE SEQUENCES IN INDIA DURING THE 1980s

B. K. RASTOGI
National Geophysical Research Institute
Hyderabad-500 007

ABSTRACT – *The fault-plane solutions, isoseismal maps, depths of earthquakes and the geological studies done for the nineteen damaging earthquakes which occurred in the Indian region during the 1980s have been synthesised and interpreted in terms of seismotectonics. Out of these, thirteen earthquakes were studied by us and six by others. These earthquakes range in intensity from IV and VIII, magnitude from 3.2 to 6.8, depth from a few hundred meters to 91 km. Some of the earthquakes were individual events and others showed long sequences of earthquakes. The seismotectonic inferences are discussed with special reference to Himalaya and Peninsular India.*

INTRODUCTION

The geological studies, macroseismic observations and determination of the fault-plane solutions for a good number of earthquakes during the 1980s provided an opportunity to understand better the seismotectonics of India. This knowledge is necessary for the realistic estimation of earthquake hazards not only in Himalaya but also in the Peninsular India. Prior to this decade, the macroseismic observations to identify the causative faults were restricted to a few strong earthquakes. During the 1980s, the macroseismic observations had been made for even smaller earthquakes due to the active interest shown by various agencies and thereby increasing the number of earthquakes studied during this decade. Moreover, aftershocks were monitored with local networks for several earthquakes.

This has given the opportunity to determine the composite fault-plane solutions in case the fault-plane solutions were not possible for the main earthquakes. These composite fault-plane solutions provide a fair idea of fault mechanism. All this data published in different papers and also new fault-plane solutions for five earthquakes worked out during this study have been synthesised to form consolidated knowledge.

During the 1970s, fault-plane solutions have been worked out for a number of earthquakes in Himalaya and Peninsular India by a number of workers[1]. However, identification of the causative fault for most of the earthquakes has been rather difficult in the absence of the knowledge of hypocentral parameters to the desired accuracy and as such, the focal mechanisms could give only a general idea of seismotectonics. For several earthquakes which occurred in the 1980s, it has been possible to correlate the focal mechanism with the causative fault due to better locations of hypocenters as well as macroseismic and aftershock studies.

EXISTING KNOWLEDGE OF SEISMOTECTONICS

Himalaya is one of the most active belts of the world, seismically, and one of the rare sites of active continent–continent collision. A major portion of the strain due to collision is taken up in the thrusting phenomenon along the Himalaya while the remaining strain is distributed north of it in a wide area from Tibetan Plateau to Pamirs. Thrusting along the suture zone started during 40–45 MYBP. At a later time, the suture became inactive and since 25 MYBP, thrusting has been along the Main Central Thrust (MCT) situated south of suture zone. Around 10 MYBP large thrusting occurred along the Main Boundary Thrust (MBT) situated further south. The MCT is of Miocene age along which the Higher Himalaya overthrust the lower Himalaya. The MBT is of mid Miocene–Pliocene age along which the older rocks of lower Himalaya thrust over the Siwaliks.

The northward movement of the Indian plate and the continued convergence process along the Himalaya has transmitted large northerly compression in the Indian Peninsula, causing NE oriented faults. The other tectonic features like ENE trending Narmada–Sone graben and NW trending Godavari and Mahanadi grabens are older.

Source parameters of damaging earthquakes in the Indian region during 1980s.

Some 19 damaging earthquakes are known to have occurred in India during the 1980s (table 1). Out of these 8 were in the Himalaya–Burma region, 10 in the Peninsula and 1 in Nicobar Islands. The earthquakes in Himalaya–Burma region were of body-wave magnitude (MB) = 5.2 – 6.8 (Modified Mercalli (MM) Intensity = VII – VIII), some of which have caused great damage. Damage due to smaller earthquakes in the Peninsular India were also reported. Hence, these earthquakes, though of small magnitude, were studied. The magnitude of the Peninsular earthquakes ranged from 3.2–5.3 (Intensity IV – VI). Though the number of earthquakes studied in Peninsular India is more, seismicity is negligible compared to that in Himalaya. In table 1, the MB and MS magnitudes are body-wave and surface-wave magnitudes, respectively from USGS. Richter scale magnitude ML is by IMD and the duration magnitude, MD is from NGRI.

Most of the intensity values are as given in the original publications, but a few are reestimated. I have generally followed the MM scale. Besides considering various damages and effects of earthquakes according to this scale, the broad guidelines followed by me are as below:

INTENSITY VIII: Several deaths by collapse of a number of houses.
VII: A few deaths or collapse of limited number of houses.
VI: Collapse of a few walls.
V: Cracks in a number of houses.
IV: Earthquake felt strongly. Minor cracks may be in a few houses.

Table 1. Damaging Earthquakes in India during 1980s.

Region	Date	Lat°N	Lon°E	Depth Km	INT	MB		Sequence	Deaths
1. Dharchula	July 7, 1980	29.60	81.09	18	VIII	5.7	6.1 ML	AUG–SEP 1980	200
2. Jammu	Aug. 8, 1980	32.89	75.56	15	VII	5.2	5.5 ML	—	15
		32.83	75.63		VII	5.2	5.4 ML	—	
3. Koyna	Sep. 20, 1980	17.25	73.70	8	VI	5.3	4.9 ML	1964–PRESENT	
4. Sikkim	Nov. 19, 1980	27.39	88.75	17	VII	6.0	6.1 MS	—	
5. Osmansagar	Jan. 14, 1982	17.40	78.30	2	IV		3.5 MD	JAN–FEB 1982	
6. Nicobar Is.	Jan. 20, 1982	6.93	94.03	19	VII	5.6	6.3 MS	JAN 20–25 1982	
		7.12	93.44	27	–	5.7	6 2 MS		
7. Hyderabad	Jun. 30, 1983	17.68	78.50	13	VI		4.5 MD	—	
8. Bhatsa	Sep. 14, 1983	19.57	73.40	5	VI		4.9 ML	1983–PRESENT	
9. Bangalore	Mar. 20, 1984	12.66	77.80	12	VI		4.6 MD	—	
10. Sriramsagar	Jul. 21, 1984	18.62	77.98	2	IV		3.2 MD	JUN–AUG 1984	
11. Tirupattur	Nov. 27, 1984	12.47	78.60	3	VI		4 5 MD	NOV 84–MAR 85	
12. Cachar	Dec. 30, 1984	24.64	92.89	5	VII	5.6		DEC–JAN 1984	11
13. Dhenkanal	Jan. 19, 1986	21 00	85.00	Shallow	VI		4.2 MD 5.0 ML	—	
14. Dharamshala	Apr. 26, 1986	32.10	76.30	2	VII		5.5 ML	—	
15. Valsad	Apr. 27, 1986	20.56	73.39	7	VI		4.6 ML	1986–PRESENT	
16. Bangladesh-NE India	Feb. 6, 1988	25.00	91.30	5	VIII	5.8		—	2
17. Idukki	Jun. 7, 1988	9 82	77.22	5	VI		4.5 MD, ML	JUN–SEP 1988	
18. Burma-India	Aug. 6, 1988	25.15	95.13	91	VIII	6.8	7.3 MS	AUG–OCT 1988	5
19. Nepal-Bihar	Aug. 20, 1988	26.76	86 62	57	VIII	6.4	6.6 MS	AUG–OCT 1988	1004

Hypocentres for Sikkim, Nicobar Islands, Bangla-desh–India border, Burma–India and Nepal–Bihar Border earthquakes are by USGS. For other earthquakes, the locations are by IMD or NGRI as USGS locations were either not available or better estimates were made with local data. It is noticed that the Burma–India Border earthquake was deepest at 91 km depth. The Nepal–Bihar earthquake had a depth of 57 km. The other earthquakes in Himalaya and Peninsula were shallow. It is further noticed that all the earthquakes in the Peninsular India were only as deep as 13 km. Sounds (as in explosion or rumbling) associated with all these earthquakes confirm this observation.

Trends of isoseismals and depths of different earthquakes are shown in figure 1. Though isoseismal trends depend mainly upon ground conditions, it is many times used to infer direction of faulting if the ground can be assumed homogeneous. Isoseismals are elongated along the fault direction and become wider in the direction of propagation of faulting. Though the latter characteristic has not been noticed for earthquakes during the 1980s, isoseismals have been found to elongate in the fault direction for many of the earthquakes during the 1980s. Hence, for the remaining earthquakes, a fault is inferred along the trend of isoseismals.

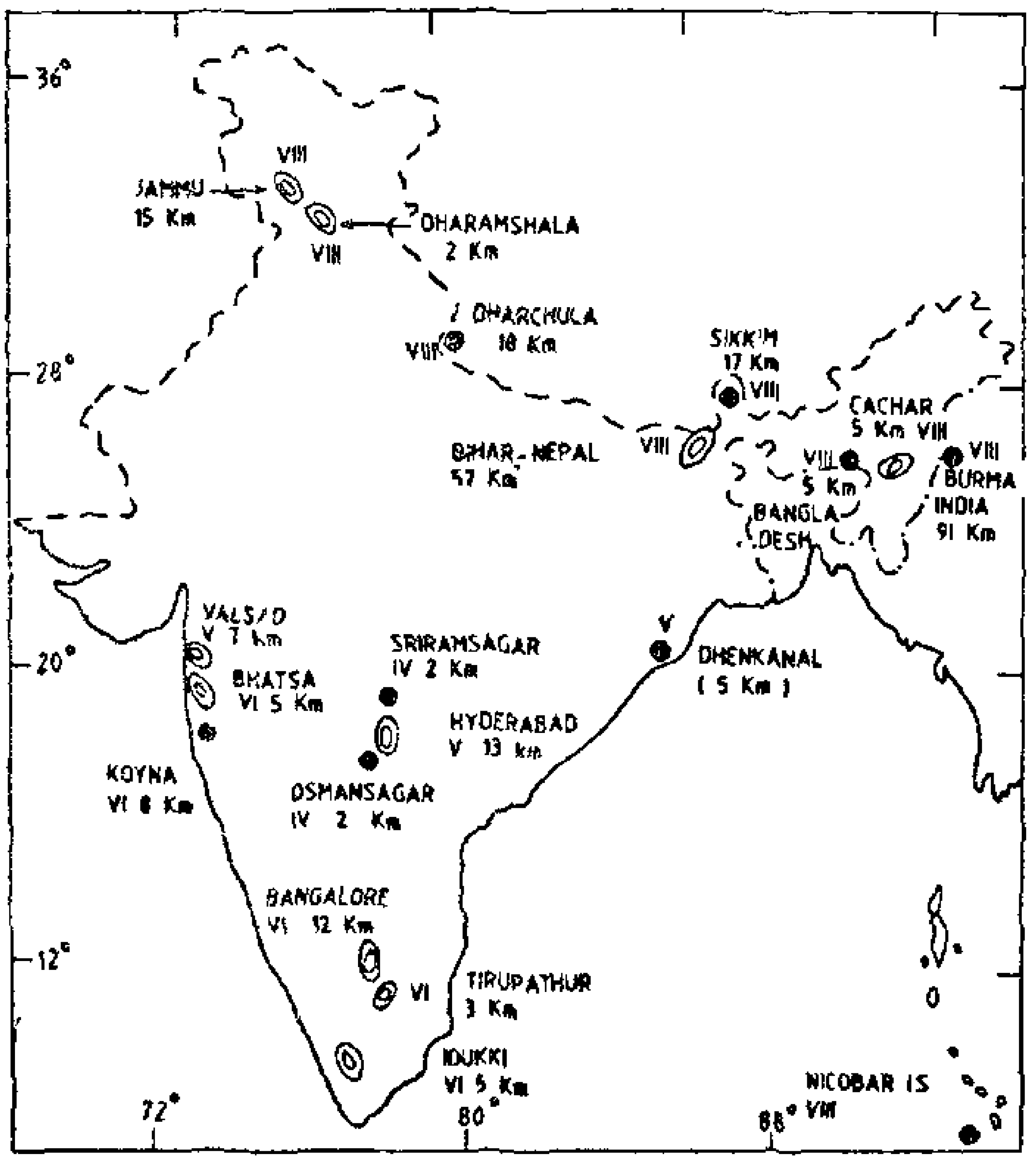

FIGURE 1 Isoseismal trends and depths of damaging earthquakes during the 1980s. Isoseismals are not to scale. Trends of the only two isoseismals, i.e. maximum, and next lower to maximum for each earthquake, are considered. Only one circle is drawn for the earthquakes where trends of isoseismals are not known.

FAULT PLANE SOLUTIONS

The type of faulting and orientation of the fault for individual earthquakes is obtained by fault-plane solutions (figure 2). These were determined by us for 13 earthquakes[2] and by others for 4 earthquakes. For Dhenkanal and Tirupathur earthquakes fault-plane solutions could not be determined. The fault plane solutions were determined using P-wave first motion directions and sometimes S-wave polarization angles. In some cases the first motions were read by the authors themselves for different stations from long-period seismograms which are more reliable, but for most earthquakes published data from long-period as well as short-period seismograms were used. Nodal planes are drawn to divide the zones of compressions (first motion up) and dilatations (first motion down) as

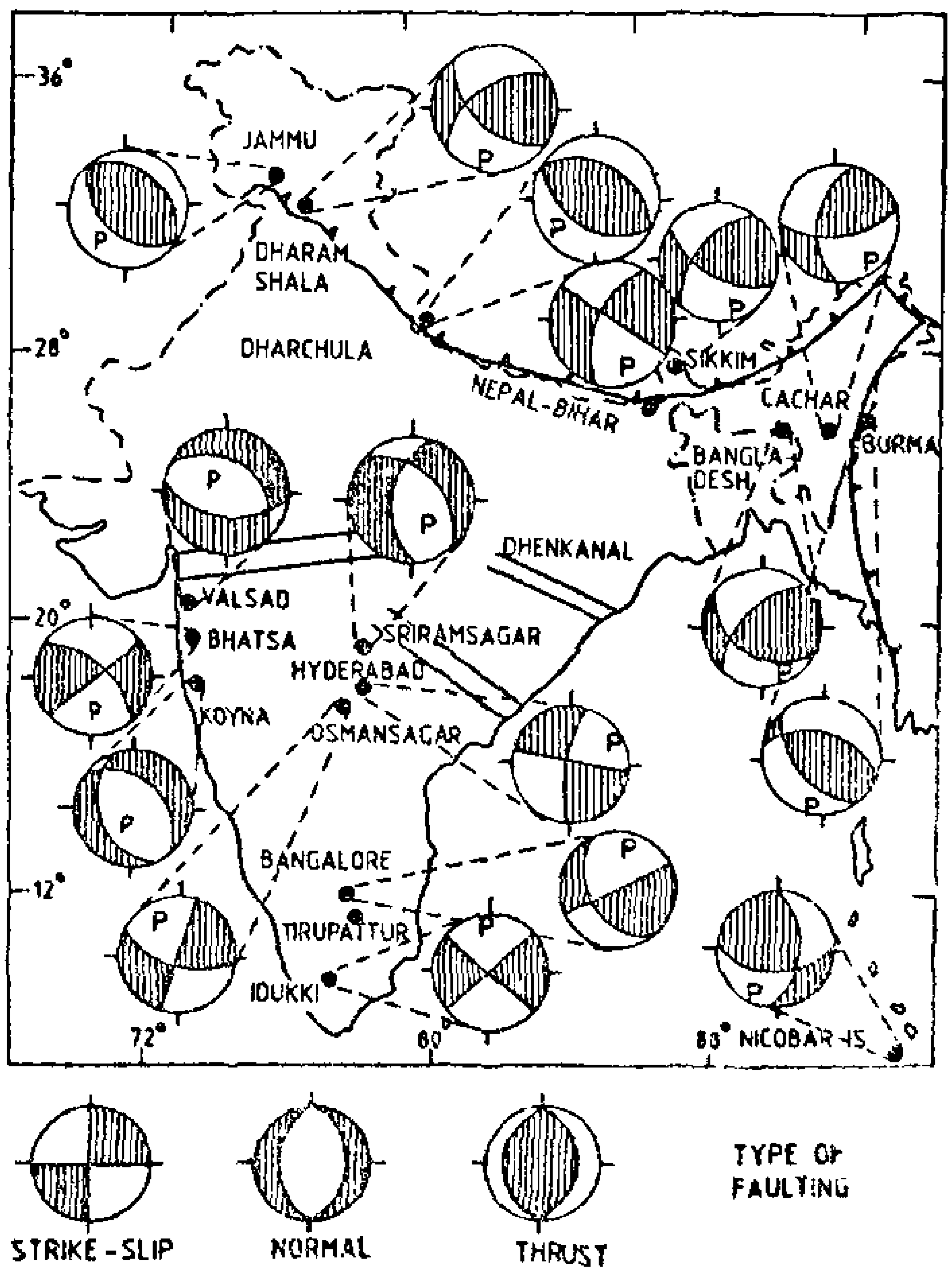

FIGURE 2 Fault plane solutions of damaging earthquakes during 1980s Lower hemisphere of equal area projection has been used. Hatched areas represent quadrants of compression. P represents the position of the pressure axis

read from vertical component seismographs. One of the two planes represents the fault plane which is chosen on the basis of isoseismal trend and geology. Fault orientation accuracy is about 15° from well-determined mechanisms. Most of the earthquakes listed in table 2 were recorded on a number of stations so that the nodal planes could be drawn fairly reliably. For some earthquakes, with less data, the nodal planes have some uncertainity, e.g. Hyderabad, Bangalore, Koyna, Sriramsagar and Bangladesh–India border earthquakes.

As the main earthquake at Osmansagar, Bhatsa, Sriramsagar, Valsad and Idukki were small and occurred in Peninsular India where the number of seismic stations are less, enough data was not available for determining fault-plane solution. We operated networks of seismic stations to study aftershocks. From the first motions of aftershocks, the composite fault-plane solutions were determined assuming that all the chosen aftershocks have the same mechanism and occur along one fault.

The sense of movement along the assumed fault is shown in figure 3 for all the earthquakes. Dharchula, Jammu and Burma–India border earthquakes showed thrust faulting. Valsad and Koyna earthquakes showed normal faulting. Sriramsagar earthquake indicated normal faulting with a strong strike-slip component. The other earthquakes showed strike-slip faulting. Right-lateral strike-slip movement is along the NW fault-plane for four earthquakes in Peninsular India, viz. Valsad, Idukki, Bangalore and Sriramsagar and one earthquake in Himalaya i.e. Dharamshala earthquake. Nepal–Bihar and Sikkim earthquake indicated left-lateral strike-slip movement along transverse faults. Bangladesh and Cachar earthquakes indicated right-lateral movement along E-W faults. In the Peninsular India Medchal and Osmansagar earthquakes indicate strike-slip movement along N-S or E-W trending fault.

The Jammu earthquake has occurred along the Main Boundary Thrust[3]. Almost all the other earthquakes have occurred along lesser known faults or lineaments. These have been described below.

Dharchula earthquake had occurred along a NW trending thrust located in between the Main Boundary Thrust and Main Central Thrust. Srivastava[3] shows many lineaments which trend NW and many transverse lineaments in NE direction in the aftershock zone which trends in the NW direction. The **Koyna earthquake** of September 20, 1980 had occurred along the NW trending normal fault. This fault is along the Warna river lineament[4].

TABLE 2. Fault-plane solutions of damaging earthquakes in the Indian Region during 1980s.

	NP1			NP2			P-axis		T-axis		N-axis			
	AZ	DIP	DIR	AZ	DIP	DIR	AZ	PLG	AZ	PLG	AZ	PLG	Type	REF
1. Dharchula	(120	20	NE	300	70	SW	210	25	30	65	120	0)	T	IMD
2. Jammu	(130	20	NE	310	70	SW	220	25	40	65	130	0)	T	IMD
3. Koyna	318	50	NE	328	40	SW	188	82	53	6	322	6	N	BKR
4. Sikkim	218	64	NW	119	74	SW	160	10	74	32	269	58	S	BKR
5. Osmansagar	22	90	—	112	80	SW	337	8	67	8	202	80	S	BKR
6. Nicobar Is.	353	81	E	87	69	S	41	8	308	21	152	67	S	BKR
	1	77	E	93	83	S	226	4	122	22	120	75	S	BKR
7. Hyderabad	4	70	W	94	90	—	48	15	142	15	274	70	S	BKR
8. Bhatsa	314	60	NE	44	90	—	175	20	274	20	44	30	S	BKR
9. Bangalore	332	60	SW	62	90	—	15	17	111	18	243	60	S	BKR
10. Sriramsagar	315	46	NE	6	56	W	152	62	253	5	345	28	N+S	BKR
11. Cachar	83	68	S	12	50	W	142	10	40	45	242	43	S	DDS
12. Dharamshala	131	69	SW	232	62	NW	183	5	90	35	279	55	S	WIH
13. Valsad	278	54	S	310	40	NE	312	73	201	7	108	17	N	BKR
14. Bangladesh-India	114	63	SW	220	62	NW	167	1	77	41	259	49	S+T	BKR
15. Idukki	310	90	—	40	90	—	355	0	85	0	—	90	S	BKR
16. Burma-India	290	45	NE	143	50	SW	217	3	119	72	308	18	T	BKR
17. Nepal-Bihar	30	60	NW	122	88	NE	171	22	73	18	307	60	S	BAN

Note Type of faulting, T = Thrust faulting, N = Normal faulting, S = Strike-slip faulting, IMD = India Met. Dept., BKR = Rastogi, DDS = Singh, WIH = Wadia Inst. Him. Geology, BAN = Banghar

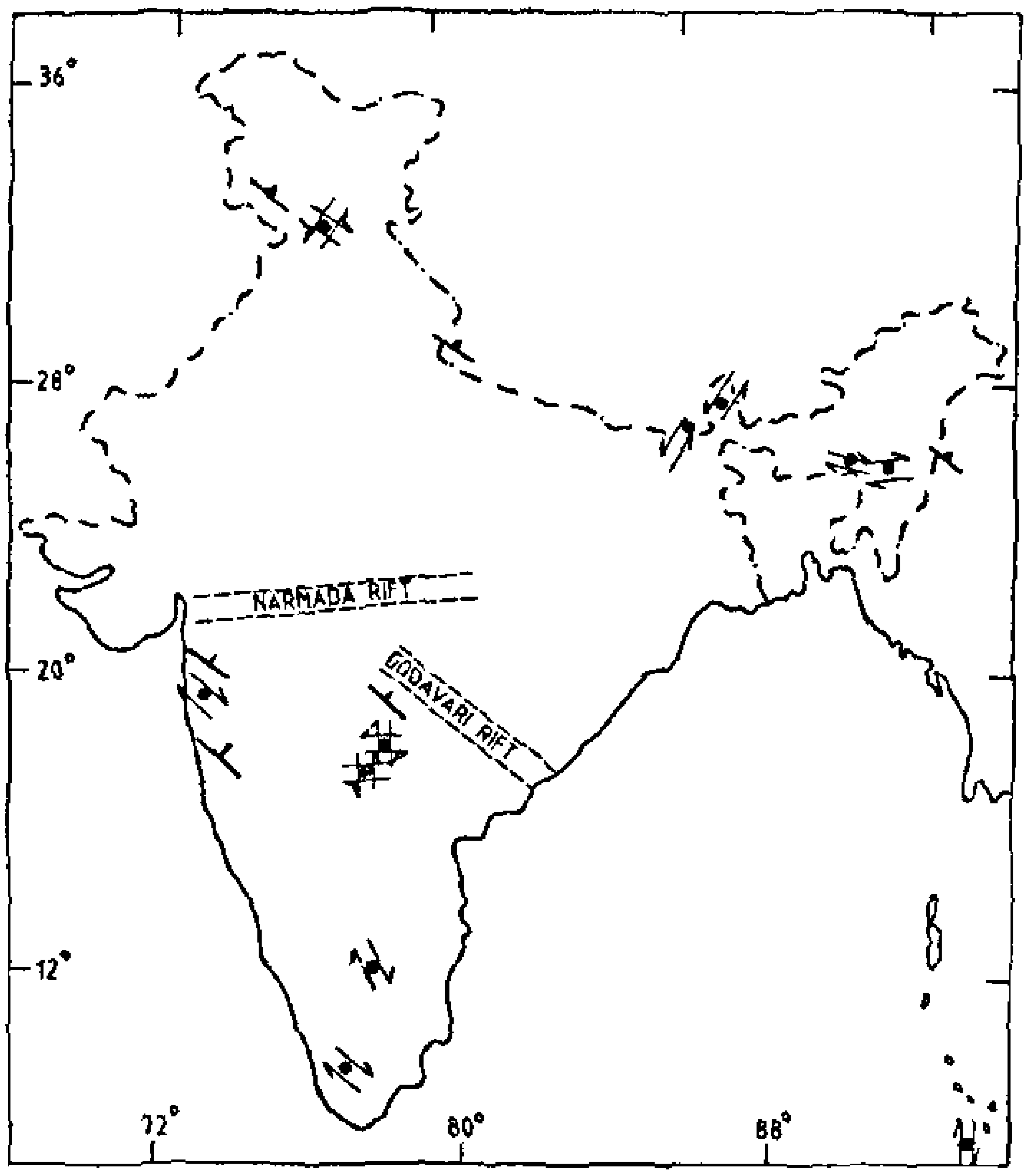

FIGURE 3 Type of faulting for damaging earthquakes during 1980s.

For the **Sikkim earthquake**, the fault plane solution determined by me from the first motions (figure 1) matches with the mechanism obtained by Khanal and Khattri[5] from wave-form analysis. The fault plane solution indicates strike-slip faulting with a large thrust component either along a NE or NW trending nodal plane. Clear choice is difficult due to lack of macroseismic data. The epicenter is about 30 kms east of Gangtok. There are no faults known in that area. The Main Central Thrust is west of Gangtok[6] and shows arcuate turn in the area having different trends in different parts.

The **Osmansagar earthquake** occurred about 20 km west of Hyderabad. The earthquake was felt in an area of about 5 km radius. The isoseismal did not show any trend. The lineaments in the area show predominant ESE, NNE and NE trends. The first two match with the nodal planes[7]. Choice of fault planes from these two trends is difficult. As a fault in NNE direction was reported to be observed in the area previously, the NNE nodal plane was preferred to be the fault plane. However, several aftershocks were aligned in ESE direction. Also, C. V. Ramakrishna Rao of NGRI (Ph.D. Thesis, 1989) has found an E-W trend of several shocks which have been located near Hyderabad for the past several years. These two evidences would favour a ESE trending fault. Similar nodal planes are obtained for the **Hyderabad earthquake** whose epicenter is about 30 km NE of Osmansagar. The lineament pattern is also similar in this epicentral area. But the P-axis direction has a difference of about 90° in azimuth for the two earthquakes[8].

The **Nicobar earthquake** indicates right-lateral slip along a N-S nodal plane or left lateral slip along the E-W nodal plane. N-S nodal plane is considered to be the fault plane in view of the N-S trend of the Andaman–Nicobar seismic zone. In the Andaman Sea area, Eguchi *et al.*[9] have determined a similar mechanism for four earthquakes. These earthquakes are attributed to ridge–ridge type transform faults.

For the **Bhatsa sequence** the composite fault-plane solution indicates right-lateral slip with some down dip normal movement along a NW fault which matches with the Kalu-Surya and Talekhan faults. These faults are parts of Ghod lineament or extension of Koyna rift[10].

For the **Bangalore earthquake** the NNW trending fault is assumed to be the fault plane as the isoseismals are elongated in that direction. Moreover, a NW set of lineaments is mapped in the area (Rastogi and Vasudev, unpublished report). The epicenter is close to a NNW trending megalineament along the Chinnar river course. Near the epicentre, nearly E-W course of the river sharply turns in NNW-SSE direction. A shear zone was observed at this point.

In the **Sriramsagar earthquake** epicentral area the predominant set of lineaments are in NW direction though NE trending lineaments are also present. Due to NW trend of epicentres and a NW trending lineament present close to the epicentral area, the nodal plane in that direction was assumed to be the fault plane[11].

For **Tirupathur earthquake** fault-plane solution could not be obtained as no data was available. This earthquake had occurred along the Eastern Ghat fault trending in NE direction. The isoseismals are extended in the same direction[12].

The **Cachar earthquake** occurred along the Bhuban fault which trends ENE (Rastogi 1985, NGRI Annual Report). The fault plane solution obtained by Singh[13] indicates that one of the nodal planes is in the same direction. Though the maximum intensity isoseismal shows a NNE trend, other isoseismals show a distinct E-W trend matching with the fault direction.

Dharamshala earthquake had occurred along the Main Boundary Thrust. The mechanism obtained at IMD shows normal faulting along the MBT[14]. As this fault plane solution has a number of inconsistent observations, I have preferred the solution given by Surendra Kumar and Mahajan (personal communication) of Wadia Institute of Himalayan Geology. They attribute the earthquake along a splay between two thrusts. This might have happened as a strike-slip movement along the NW trending fault and which would be consistent with the NW elongation of isoseismals[15]. The mechanism of this earthquake is to be further checked in view of the large difference in the results obtained by IMD and WIHG.

For the **Valsad earthquake sequence** the composite fault plane solution indicates normal faulting. The nodal plane trending NW is considered to be the fault plane because of NW trend of isoseismals and the epicenters. A more number of lineaments are mapped in the NW direction in the area. NE trending lineaments are also present in the area. E-W trending nodal plane could also be the fault which is in the direction of the Tapti lineament situated at about 60 km north of the area as the epicenters determined by us for only the large shocks were found to be trending EW. Moreover Rao *et al*[16]. mentioned that the lineaments in different directions may be active in the area.

The composite fault-plane solutions for the **Idukki earthquake** sequences indicates nodal planes in NE and NW direction. The latter is considered to be the fault plane as the earthquakes are found to be associated with the NW trending Periyar river lineament and the isoseismals are also elongated in the NW direction[17].

The **Nepal-Bihar earthquake** had occurred along the NE trending East Patna fault[18]. Isoseismals trend in the same direction. The epicenter is near MBT upto which the East Patna fault can be extended. Locally a NE trending fault is plotted on the geological map prepared by the Department of Mines and Geology, Nepal. This has been retraced by Rastogi[19].

Discussions

In this paper we have described the seismicity of the decade of the 1980s. For a longer duration, the nature of seismicity may reveal certain aspects not observed during the 1980s. For example, four earthquakes in the Peninsula occurred along NW faults and two along N-S or E-W faults near Hyderabad and none along the NE trending faults during the 1980s. However, during 1960s and 1970s several earthquakes showed faulting along NE trending faults[1]. These NE faults are considered to be younger than the NW trending faults which slipped in the 1980s. All the known aspects from the previous studies have been considered for our interpretation.

The seismicity in Himalaya has been strong with several severe earthquakes of intensity VII–VIII killing thousands of people. Compared to it, the strongest earthquakes in Peninsula were mild with intensity IV–VI. The deeper earthquakes in Himalaya have been the largest for example, Nepal–Bihar earthquake (MS = 6.6, h = 57 km) and Burma–India Border earthquake (MS = 7.3, h = 91 km).

Two types of forces are likely to be present in the Indian region. The southward push from the Asian side which gave rise to thrusting in the Himalaya. The northward movement of the Indian plate caused by expansion of mid-oceanic ridges which generated compression in the Himalaya and Indian Peninsula. The effect of the geothermal source which might give rise to tension across the Narmada–Tapti, Godavari, Koyna paleo-rifts also needs attention in this regard.

Jammu and Dharchula earthquakes in Himalaya and the Burma earthquake showed thrust faulting due to compression in Himalaya. Nepal, Sikkim and Cachar earthquakes in Himalaya showed strike-slip faulting along the transverse features. The transverse faults in Himalaya are also due to compression. These exist as boundary between different thrusting blocks.

The P and T axes from the fault-plane solutions are generally believed to represent the axes of compressive and tensile stresses. The pressure axis is marked by P in figure 2. The P axis is nearly horizontal for strike-slip and thrust type mechanisms but nearly vertical for normal faulting. Figure 4 shows more clearly the stress pattern. In this figure, the directions of P-axis for thrust

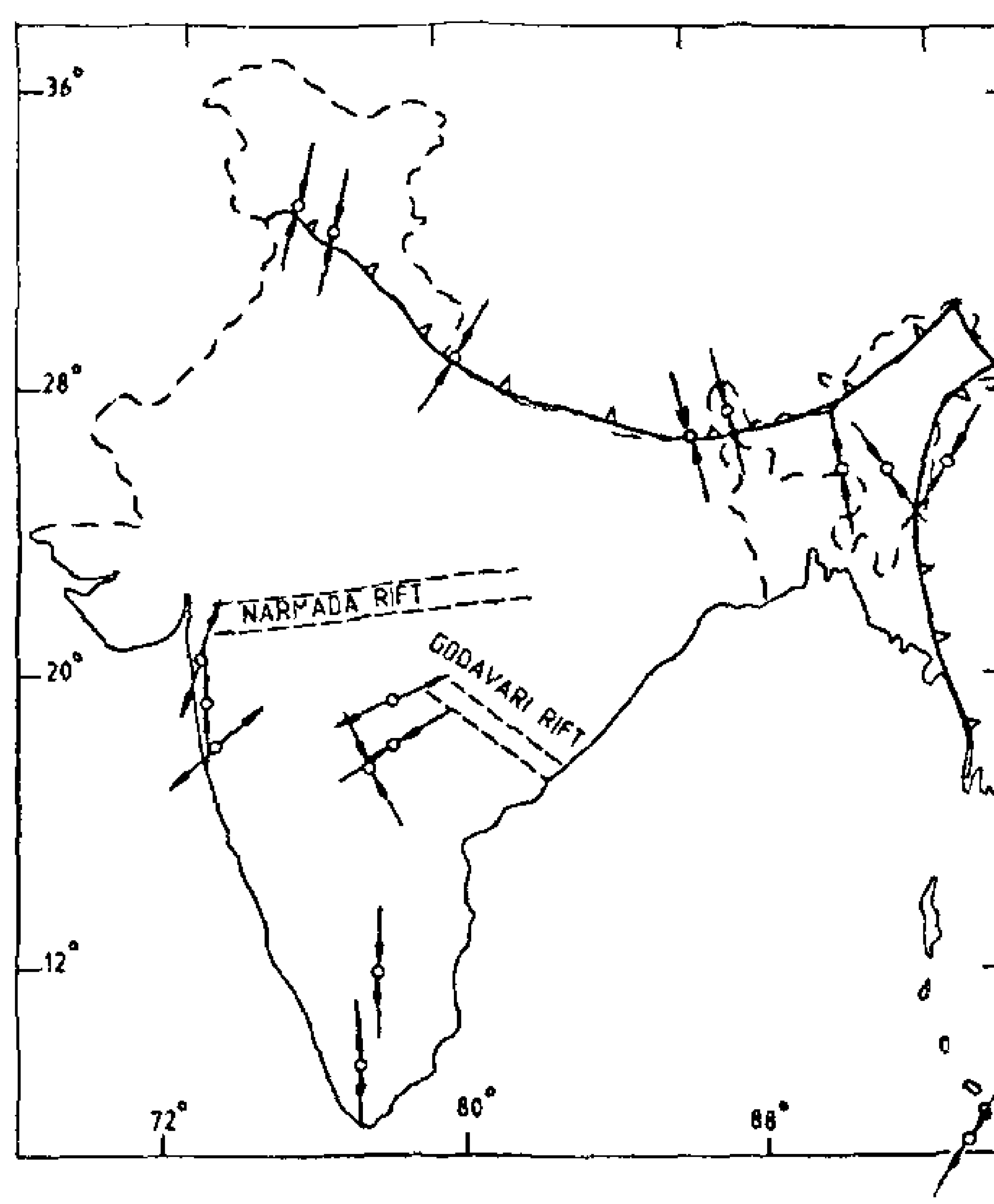

FIGURE 4 Axis of compression (in case of thrust and strike-slip faulting) and axis of tension (in case of normal faulting) for damaging earthquakes during the 1980s.

and strike-slip faults as well as Tension axis-T from normal faults are plotted.

The important finding from this figure is that the tension still prevails across Narmada–Tapti, Godavari and Koyna rifts. The pressure axis in the peninsula is in NS to NNW direction for four earthquakes. For Medchal earthquake the compressive stress is trending NE. In Himalaya the compressive stress is nearly perpendicular to the Himalayan trend being NNE to NE in the western Himalaya and NNW to NW in the eastern Himalaya. The Bangladesh earthquake shows right-lateral strike-slip faulting along a E-W trending fault. It is not clear whether it occurred along the Dauki fault or some fault in Bangladesh. The epicenter is estimated near Dauki fault, but the damage is more in Bangladesh.

In Peninsular India strike-slip faulting for earthquakes at Bhatsa, Idukki, Osmansagar, Hyderabad and Bangalore indicate that compressional stress exists in the Peninsula.

The normal faulting obtained for Valsad, Koyna and Sriramsagar earthquakes indicates the possibility that tension still prevails across the Narmada, Koyna and Godavari rifts. Normal faulting may be generated due to geothermal stresses or the triggering of pre-existing normal faults.

Right-lateral strike-slip faulting along N-S fault for Nicobar earthquake indicates NNE-SSW compressive stress. According to Eguchi et al[9]., the tectonics in Andaman Sea is a result of ridge–trench collision.

The stress pattern as observed for 1980's (figure 4) indicates N-NE compressive stress in the Indian Peninsula, NW Himalaya and western part of Nepal Himalaya. In some parts of southern peninsula and eastern part of Himalaya the compressive stress is in NW-NNW direction. These directions are consistent with earlier observations. A new observation is the finding of tensional stress regime near Narmada, Koyna and Godavari rifts.

The earlier observations of stress patterns were described by various workers eg. Chandra[1]. The salient observations include compression perpendicular to Himalayan trend for most earthquakes. Some earthquakes indicate tensional foci caused by flexure of the lithospheric plate. The peninsula has a general north–south compression. Zoback et al.[20] have described the global patterns of tectonic stress. The most reliable data for the Indian region as given in this publication shows the above observations for Himalaya. For the peninsula the compressive stress is found to be trending mostly NE with the exception of Koyna earthquake of 1967 which shows NNW compression.

Gowd et al. (NGRI Annual Reports 1982–83, 1984–85, 1985–86, 1986–87 and 1987–88) have carried out in situ stress measurements by hydrofracturing at different places in Peninsular India. The stresses are observed to be high at Kolar (555 bars at 3 km depth), Hyderabad (102 bars at 150 m), Malanjkhand (200 bars at 350 m), Mosabani Copper Mines, Bihar (83 bars at 250 m). The direction of maximum compressive stress is in general NE direction.

Gowd et al. (1988–89 NGRI Annual Report) have estimated compressive stress directions by wellbore breakout data. They have found the following results which in general match the other observations.

- NNE to ENE in Peninsular India (west of 87°E and barring southern part) as well as in north-western and Central Himalaya.
- NW in Godavari and Cauvery basins.
- E-W in Bengal basin due to subduction towards east.
- N-S at Badarpur and Masimpur (near Cachar i.e. east of Shillong Plateau) due to the effect of E-W trending Shillong Plateau.
- In upper Assam, at one place NNW and four places NNE to ENE.

CONCLUSIONS

It is known that Himalaya is seismically one of the most active belts of the world. It is also one of the few active continent–continent collision boundaries. The push from the Asian side has given rise to compression from north to south producing gigantic thrusts in Himalaya. The transverse strike-slip faults exist as the boundaries between different thrusting blocks to facilitate their movement.

Northward movement of the Indian plate has caused compression in the peninsula which has generated the NE trending faults. The compressive stress gives rise to occassional slip along these faults. The older NW trending faults also are triggered by the compression. Both these sets of faults are small in dimension. Hence, only moderate earthquakes have occurred in the Peninsula except those in the Cutch region. During the 1980s in the Indian Peninsula, the older NW trending faults have been activated by right-lateral slip for four earthquakes in response to N-S compression. The normal faults along the Narmada–Tapti, Godavari and Koyna paleo-rifts are probably due to the triggering of pre-existing faults which are triggered in the compressional regime. The possibility of generation of tensional stress across these paleorifts due to geothermal sources during the present time needs attention.

In almost all the epicentral areas of earthquakes studied by us, the pre-existing zones of weaknesses in the form of faults/lineaments have been identified excluding the possibility of the creation of new faults due to these earthquakes.

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