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A Perspective of historical earthquakes in India and its neighbourhood upto 1900

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सार — प्राचीन काल से लेकर 19 वीं शताब्दी तक की अवधि के दौरान भारत और इसके समीपवर्ती क्षेत्रों में घटी भूकम्प के पश्चात की गतिविधियों पर अध्ययन किया गया है। इसवीं सन् की छठी शताब्दी में महान भारतीय खगोलशास्त्री वराह मिहिर ने अपनी पुस्तक 'बृहत संहिता' में भूकम्पों की खोज का उल्लेख किया है। उनकी खोजों का संक्षिप्त विवरण और उनके संबंध में विश्लेषण इस शोधपत्र में दिया गया है। वैज्ञानिक रिपोर्टों और कुछ इतिहास और भूगोल की पुस्तकों के आधार पर भारत और इसके समीपवर्ती 0° और 40° उ अक्षांशों के मध्य तथा 60 ° पू और 100 ° पू देशांतरों के मध्य के क्षेत्रों में सन् 1900 तक आए 6 और इससे अधिक परिमाण वाले भूकम्पों की सूची तैयार की गई है। 8 और इससे अधिक परिमाण वाले भूकम्पों का संक्षिप्त विवरण भी इसमें शामिल किया गया है।

ABSTRACT. A study has been carried out on past seismic activity in India and its neighbourhood from ancient times to nineteenth century. During sixth century AD, the great Indian astronomer Varaha Mihira investigated earthquakes in his book 'Brihat Samhita'. A brief description and analysis on his investigations have been cited. Based on scientific reports and a few history and geography books, a list of earthquakes of magnitude 6 and above upto 1900 AD has been prepared for India and its neighbourhood in the region bounded by latitude between 0° and 40° N and longitude between 60°E and 100°E. A brief description of earthquakes of magnitude 8 and above has also been included.

Key words — Earthquake catalogue, Historical earthquakes, Past seismicity.

1. Introduction

In India, earthquakes are being studied for a long time. A glimpse of ancient literature shows that during sixth century AD the great astronomer Varaha Mihira investigated earthquakes in his book "Brihat Samhita". The results of his investigations have been briefly described and analysed in section 2. Further in section 3, a preliminary list of earthquakes of magnitude 6 and above upto 1900 AD in India and its neighbourhood have been compiled. The exact region considered here is bounded between latitude 0° and 40°N and longitude 60°E and 100°E. The list is compiled mainly on the basis of available scientific reports and catalogues. There are abundant references of earthquakes in the books on history and geography such as, James (1975) and Kaul (1971). It is felt that the proposed list can significantly be improved upon if other such books are consulted.

2. Studies of Varaha Mihira

During 6th century AD Varaha Mihira described his investigations on earthquakes in chapter 32 of his book "Brihat Samhita" (Tripathi 1968, Bhat 1981). He catagorized earthquakes in 4 classes according to the causes of their occurrence. The classifications are:

(*i*) Vayabya caused by 'Vayu', the wind)

(*ii*) Varuna (caused by 'Varuna' the God of water)

(*iii*) Aindra (caused by 'Indra', the ruler of sky and God of thunder)

(*iv*) Agniya (caused by 'Agni', the fire)

Vayabya earthquakes are felt along a distance of 200 yojans or about 1600 km, *i.e.*, 800 km around the epicentre. With the present day scale, this corresponds to an earthquake of magnitude 8.5. In such an earthquake, aftershocks continue for two months. According to Varaha Mihira, such earthquakes occurred in Saurashtra, Matsya (Jaipur). Kuru (Thaneswar, Hissar and Meerut region between Yamuna and Ganga), Magadh (districts of Patna and Gaya in Bihar) and Dasarna (eastern Malwa and adjoining part of Chhatisgarh).

Varuna earthquakes are felt at a radius of about 720 km and correspond to magnitude little above 8. An earthquake of this type is accompanied by aftershocks which occur on

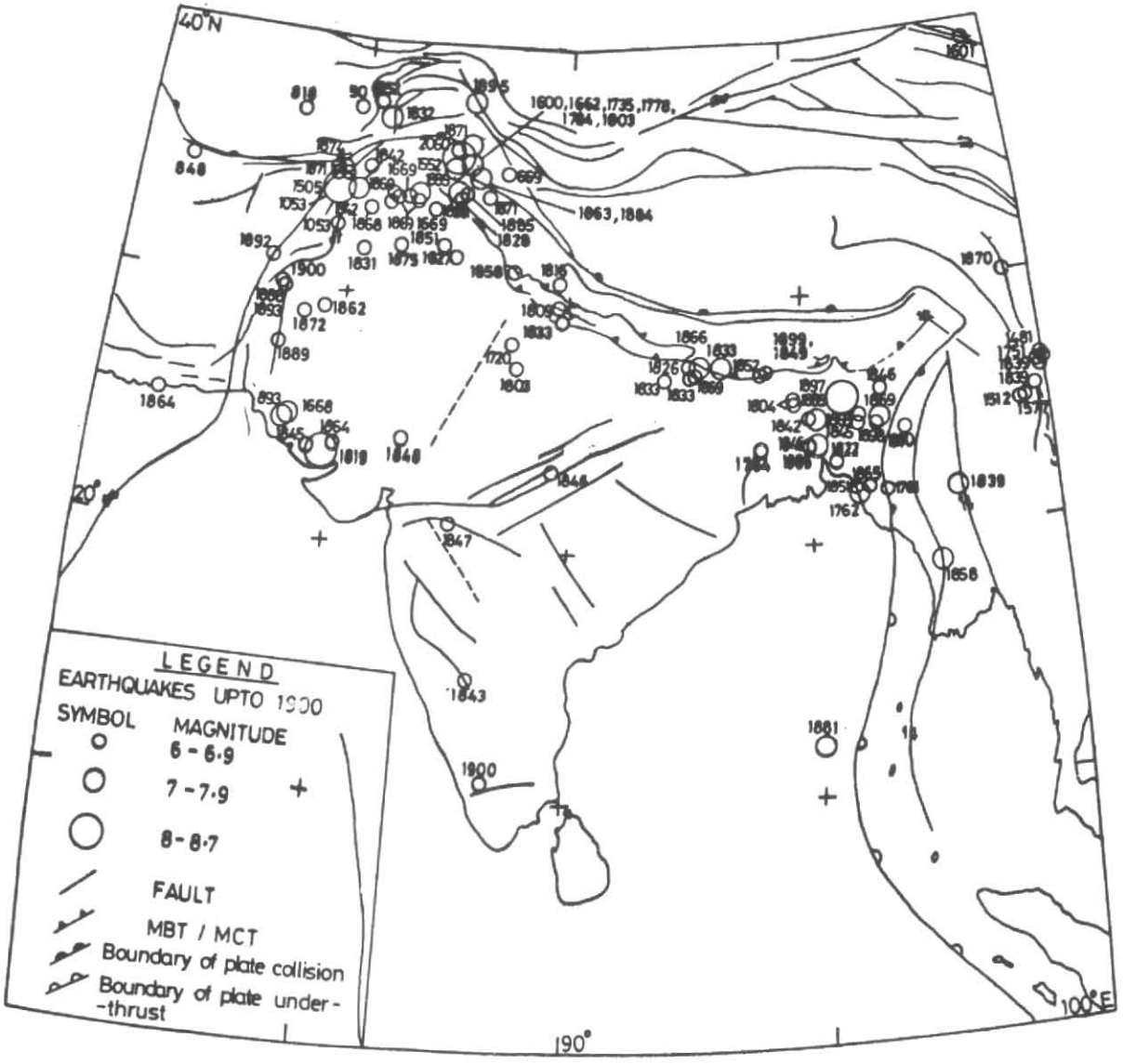

Fig.1. Location of epicentres along with tectonic features. The number by the side of a location shows the year of occurrence in AD unless otherwise mentioned.

TABLE 1
Magnitude assessment based on intensity (MM scale)

Intensity	VIII-	VIII	VIII+	IX-	IX	IX+	X-	X	X+	XI	XII
Magnitude	6.0	6.3	6.5	6.8	7.0	7.3	7.5	7.7	8.0	8.4	8.7

the same day. Such earthquakes occurred at Chedi (Bundelkhand and adjoining part in Madhya Pradesh). Gonandha (Punjab), Kukura (western Rajasthan around Barmer), Kirata (Tripura) and Videha (North Bihar).

Aindra earthquakes are felt about 640 km around the epicentre and this corresponds to an earthquake of magnitude 8. Aftershocks occur for a week. Such earthquakes occurred in Kasi (country around Varanasi), Kirata (Tripura), Yugandhra (west bank of Yamuna from Delhi to Mathura), Abhishara (Hazara), Arbuda (Mount Abu), Hala (Hills in the west of lower valley of Indus), Madra (country between Rabi and Chenab), Kira (Kangra valley), Malwa, Saurashtra (Surat).

Agniya earthquakes are felt 440 km around the epicentre. This corresponds to an earthquake of magnitude 7. Aftershocks continue for one and a half month. Such earthquakes occurred at Anga (central Bihar around Bhagalpur and adjoining part of Bengal), Banga (Bengal), Kalinga (southern Orissa and northern part of coastal Andhra Pradesh, Tangana [Uttar Pradesh (UP) hills], Balhika (country between Beas and Sutlej rivers), Dravida (Tamilnadu) and Asmake (country around Godavari river).

The locations identified in bracket for the places of ancient period are based on Shastri (1969) and Dey (1979). Varaha Mihira described the types of earthquakes in the following order:

Vayabya, Agniya, Aindra and Varuna; period of aftershock occurrence decreases in this order. However, the types of earthquakes in order of assessed magnitude are Vayabya, Varuna, Aindra and Agniya. The assessment of magnitude in the paper is based on the felt area. Although felt area increases with magnitude but it may also increase with focal depth which we are unable to assess from the description of Varaha Mihira. Further, the above assessment of magnitude using present day perceptibility scale, as inferred here, may not be proper. It is likely that human perceptibility of sound and ground vibration during ancient times might be higher than the present one as the pollution of sound and vibration was much less during those days. Thus actual magnitude may be one or two unit less than that assessed above.

Nevertheless, the study of Varaha Mihira gives us a fairly good idea of seismically active areas where moderate to large earthquakes occurred. One belt runs north to south along Hazara, Jammu & Kashmir, Punjab, Himachal Pradesh, UP hills & western Border areas of UP, Delhi and Jaipur. Second belt starts at Surat and moves northward to Saurashtra and southern Rajasthan and then runs eastward to Madhya Pradesh, southeast UP, Bihar, Bengal and Tripura. The third belt is along central Kerala and east coast from Tamilnadu to southern Orissa through coastal Andhra Pradesh.

3. The earthquake list

As a base of proposing this list of earthquakes of magnitude 6 and above, we have considered the catalogue of Tandon and Srivastava (1974), which mainly follows the list of Oldham (1883) for earthquakes upto 19th century. The catalogue of earthquakes from historical times to 1979 for the region between latitude 0° and 50°N and the longitude 50°E and 100°E published by the Indian Society of Earthquake Technology (Bapat *et al.* 1983) was also examined. Quittmeyer and Jacob (1979) prepared a list of earthquakes for the northwestern part of the present region and Umesh Chandra (1992) for the Himalaya and its neighbourhood. These authors considered the work of Ambrasseys *et al.* (1975), Heuckroth and Karim (1970), Milne (1912), Oldham (1883), Griesbach (1893) and West (1935). Min and Shen (1983) prepared earthquakes catalogue for Yunnam Province, China. Thus the catalogues of Tandon and Srivastava (1974) and Bapat *et al.* (1983) have been improved mainly on the basis of catalogues prepared by Quittmeyer and Jacob (1979), Umesh Chandra (1992) and Min and Shen (1983).

Here for many earthquakes we have assessed the magnitudes which were not mentioned by Bapat *et al.* (1983). However, we have also added data from reports of GSI, Statesman (daily newspaper) and some history and geography books (Kaul 1971, James 1975). The magnitudes have been assessed according to Table 1 on the basis of reported Modified Mercalli (MM) intensity. A catalogue of earthquakes for the peninsular India for the period 1839 to 1900 was prepared by Srivastava and Ramachandran (1985) based on the newspaper reports; this catalogue contains several earthquakes which was not known earlier. The magnitudes for the earthquakes in this catalogue were less than 6 and thus not included in the present list.

Oldham (1883) referred to an earthquake in Calcutta accompanied by hurricane and flood on the 11 October 1737 that is responsible for loss of 300,000 lives. However, Bilham (1994) has shown that evidence of such an earthquake of magnitude 6 and above is weak; thus this earth-

TABLE 2

List of historical earthquakes of magnitude 6 and above in India and its neighbourhood upto 1900

Date	Lat. (°N)	Long. (°E)	Place	Intensity	Mag.	Source
2082-2041 BC	34.4	74.5	Wular lake near Srinagar, J&K	XI	8.4	K
25 AD	33.7	72.9	Taxila	IX+	7.3	A
50	37.2	69.5	Aikhanum Afgan	VIII+	6.5	AH
180	39.4	99.5	Kansu China	-	7.5	J
818/819	36.8	66.9	Balkh Afgan	VIII	6.3	H
848/849	34.4	62.2	Heart, Afgan	VIII	6.3	H
893/894	24.8	67.8	Daibul (Dapul)	IX	7.0	O
1052/1053	32.9	69.1	Urgun, Afgan	VIII	6.3	H
1481 Jul 15	26.5	99.9	Yunnam, China	VIII+	6.5	C
1500	34	75	J & K	X-	7.5	K
1505 Jul 06	34.6	68.9	Paghman (near Kabul)	X+	8.0	AO
1512 Oct 08	25.0	98.5	Myanmar -Yunnam (China) border	IX-	6.8	C
1552	34.0	74.5	Nandarmarg, J&K	X-	7.5	K
1554 Feb	35	75	Kashmir	X	7.7	B
1577 Mar 13	25.0	98.5	Myanmar-Yunnam (China) border	IX-	6.8	C
1609 Jul 11	39.2	99.0	Kansu, China	-	6.8	C
1662	34	75	J & K	X-	7.5	K
1668 May (2-11)	25	68	Delta of Indus (Samawani or Samaji town)	IX+	7.3	OM
1669 Jun 04	33.4	73.3	Mandran Pak-Kashmir (India) border	VIII+	6.5	OM
1669 Jun 22	35	77	Kashmir	VIII-	6.0	AOM
1669 Jun 23	33.9	72.3	Attock Pak	VIII+	6.5	AOM
1688 Jun 14	26.5	99.9	Yunnam, China	VIII+	6.5	C
1720 Jul 15	28.7	77.2	Delhi	VIII+	6.5	OM
1735	34	75	J & K	X-	7.5	K
1751 May 25	26.5	99.9	Yunnam, China	IX-	6.8	C
1761 Jan 01	22.0	93.0	Arakan	VIII	6.3	B
1762 Apr 02	22.0	92.0	Off coast of Chittagong, Bangla	XI	7.5	O
1764 Jun 04	24	88	Banks of Ganga	VIII	6.3	O
1778	34	75	J & K	X	7.7	K
1784	34	75	J & K	IX+	7.3	K
1803	34	75	J & K	IX	7.0	K
1803 Sep 01	27.5	77.7	Mathura, U.P.	IX-	6.8	O
1809	30.0	79.0	Garwal, U.P.	VIII-	6.0	OM
1816 May 26	31	79	Gangotri, U.P.	VIII	6.3	O
1819 Jun 16	23.6	68.6	Runn of Kutch	X+	8.0	AOR
1822 Apr 03	23.5	91.0	Comilla, Bangla	VIII-	6.0	O
1826 Oct 29	28	85	near Kathmandu	VIII-	6.0	O
1827 Sep 24	31.6	74.4	Lahore, Pak	VIII+	6.5	AOM
1828 Jun 06	34.0	74.5	near Srinagar	IX+	7.3	AOM
1831	31.8	70.4	Daraban, Pak	VIII	6.3	AHO
1832 Jan 22	37	71	Hindukush	IX-	6.8	AHO
1832 Feb 21	37.3	70.5	Badakhshan PR.	VIII+	6.5	AO
1833 May 30	29.4	79.6	Lohughat	VIII-	6.0	O
1833 Aug 26	27.5	86.5	near Kathmandu	X	7.7	O

TABLE 2 (*Contd.*)

Date	Lat. (°N)	Long. (°E)	Place	Intensity	Mag.	Source
1833 Oct 04	27	84	Nepal-Bihar (India) border	IX	7.0	O
1833 Oct 18	27	85	Nepal-Bihar (India) Border	VIII	6.3	O
1834 Jul 08	25.8	89.4	Rangpur, Bangla	VIII	6.3	O
1834 Jul 21	25.8	89.4	Rangpur, Bangla	VIII-	6.0	O
1839 Feb 07	26.1	99.9	Yunnam, China	VIII	6.3	C
1839 Feb 23	26.1	99.9	Yunnam, China	VIII	6.3	C
1839 Mar 23	21.9	96.0	Amarapoora Myanmar	X	7.7	O
1840 Jan 26	34.5	69.2	Kabul	VIII	6.3	O
1842 Feb 19	34.5	70.5	Jalabad Alingar valley	VIII+	6.5	AH
1842 Nov 11	25	90	Pabna, Bangla	IX-	6.8	O
1843 Apr 01	15.2	76.9	near Bellary	VIII-	6.0	O
1845 Jun 19	23.8	68.8	Lakhpat (Kutch)	VIII-	6.0	M
1845 Aug 06	24.8	91.8	near Sylet, Bangla	VIII-	6.0	O
1846 May 27	23.0	80.0	Hills of Damoh, M.P.	VIII-	6.0	O
1846 Oct 18	24.5	90.4	Mymensingh, Bangla	VIII	6.3	O
1846 Dec 10	26	93	Assam	VIII	6.3	O
1848 Apr 26	24.5	72.7	near Mt. Abu	VIII-	6.0	O
1849 Feb 27	27.0	88.3	Darjeeling	VIII	6.3	O
1851 Jan 08	22.3	91.8	Chittagong, Bangla	VIII	6.3	O
1851 Jan 21	32.0	74.0	Lahore, Pak	VIII	6.3	O
1852 Jan 24	34.0	73.5	Upper Sind, Murree hills	VIII	6.3	OM
1852 May	27.0	88.3	Darjeeling	IX	6.8	O
1858 Aug 11	31.1	77.2	Simla	VIII-	6.0	AO
1858 Aug 24	19.3	94.8	Thayetmyo Brick Myanmar	X-	7.5	O
1862	29.9	69.2	Kohn Valley, Pak	VIII	6.3	W
1863	33.5	75.5	Kruhen & Bangil , J & K	IX	7.0	K
1864 Apr 29	24	70	near Ahmedabad & Surat	VIII-	6.0	O
1864 Jul 25	25.1	62.3	Gwadar, Pak	VIII-	6.0	O
1865 Dec 19	22.5	92.0	Chittagong, Bangla	VIII	6.3	O
1866 May 23	27.7	85.3	Kathmandu	VIII-	6.0	O
1868 Jun 30	24.9	91.9	Sylhet, Bangla	VIII-	6.0	O
1868 Aug 11	34.0	71.5	Peshawar, Pak	VIII-	6.0	AO
1868 Nov 10	33.0	70.6	Bannu, Pak	VIII-	6.0	AO
1869 Jan 10	25	93	near Cachhar	IX	7.0	O
1869 Apr	34.0	71.6	Peshawar, Pak	VIII-	6.0	OM
1869 Jul 07	27	85	near Kathmandu	IX	7.0	O
1869 Dec 20	33.7	72.6	Campbellpore near Rawalpindi	VIII-	6.0	AO
1870 Apr 11	30.0	99.0	Szechwan, China	-	6.5	J
1871 Apr	34	76	Kashmir	VIII-	6.0	A
1871 May 22	35.9	74.3	Gilgit	VIII-	6.0	A
1871 Nov	34.5	69.2	Kabul	VIII-	6.0	A
1872 Dec 15	29.9	68.2	Lahri, Pak	IX+	7.3	M
1874 Oct 18	34.1	69.2	Jabal Al Siraj near Kabul	IX-	6.8	AH
1874 Nov	34.5	69.2	Kabul	IX-	6.8	M
1875 Dec 12	33.5	73.0	Hazara	VIII	6.3	AM
1878 Mar 02	33.6	71.4	Kohat, Peshawar	VIII-	6.0	A

TABLE 2 (*Contd.*)

Date	Lat. (°N)	Long. (°E)	Place	Intensity	Mag.	Source
1880 Jun 19	24.5	94.0	Manipur	VIII	6.3	S
1881 Dec 31	8.6	81.2	Trincomalle Srilanka	-	7.5	MG
1884 May 30	33.5	75.5	Kruhen, J&K	IX+	7.3	K
1885 May 30	34.1	74.6	Sopor, J&K	VIII+	6.5	AM
1885 Jun 06	34.2	75.0	Kashmir	IX	7.0	M
1885 Jul 14	24.5	89.7	Sirajgang, Khamakhil (Bangla)	IX	7.0	S
1888 Dec 28	30.2	67.0	Quetta, Pak	XI-	6.8	M
1889	27.8	67.2	Jhalawan, Pak	VIII	6.3	W
1892 Dec 20	31.0	66.4	Chaman, Pak	IX-	6.8	HM
1893 Feb	30.2	67.0	Quetta, Pak	IX-	6.8	M
1897 Jun 12	25.9	91.0	Shillong Plateau	XII	8.7	MG
1898 Apr 20	24.8	92.8	Silchar	VIII	6.3	S
1899 Sep 25	27.0	88.3	Darjeeling	VIII	6.3	M
1900 Feb 08	10.7	76.7	Coimbatore	-	6	L
1900	30.4	67.0	Quetta-Pishin, Pak	VIII	6.3	W

Source index:

A — Ambraseys *et al.* (1975)

B — Burgess (1975)

C — Min and Shen (1983)

G1 — GSI records v. 17, pt. 2, pp.47-53 by R.D. Oldham (1884)

G2 — GSI report (1885) by M.R. Jones

G3 — Oldham R.D. (1899)

H — Heuchroth and Karim (1970)

J — Lee *et al.* (1976)

K — Kaul (1971)

L — Basu (1964)

M — Milne (1912)

O — Oldham T. (1882),
R — Griesbach (1893)

S — Statesman (daily newspaper)
W— West (1935)

N.B.: In the table we have used Pak for Pakistan, Bangla for Bangladesh and Afgan for Afghanistan.

quake has not been included in the present catalogue.The catalogue of earthquakes thus prepared is given in Table 2 and epicentres are plotted in Fig.1. Many earthquakes are seen to occur in Pakistan and adjoining Afghanistan, Kashmir and Kutch. A large number of earthquakes occurred along eastern Nepal, Bengal (undivided), northeastern states to Myanmar. In the peninsular India (excluding Kutch) earthquakes of magnitude 6 and above are infrequent although six earthquakes occurred in 19th century only.

4. Earthquakes of magnitude 8 and above

During the period covered in the list (Table 2) there may be some more earthquakes of magnitude 8 and above for which no record is found by the author. However, in the following lines we give a brief description of four such earthquakes listed in Table 2.

(a) *Wular Lake, Srinagar (India) earthquake, 2082-2441 B.C.*

This earthquake occurred during the rule of Sumander Sena (Kaul 1971). It is described that a destructive earthquakes occurred during night by which, in the middle of the city of Sandimatnagar, there were fissures on the earth; water gushed out through fissures and submerged the whole city. This submerged city forms the bed of the Wular lake which is situated only 35 km northwest of Srinagar. The maximum MM intensity appears to be XI.

(b) *Paghman, Afhganistan earthquake, 1505 A.D.*

The effect of the earthquake was seen in the area north-northwest of Kabul (Oldham 1883, Heuckroth and Karim (1970), Ambrasseys *et al.* 1975). Maximum MM intensity X+ was seen at Paghman (34°60′ N, 68°93′E). This earthquake occurred in the northern position of Chaman fault Fig.1. Surface faulting was observed and extended for approximately 60 km in a northnortheast direction along the base of the Paghman mountains where vertical displacement of several meters was observed. The observations suggest that the fault movement may have both strike-slip and dip slip components (Quittmeyer and Jacob 1979).

(c) *Rann of Kutch, India earthquake, 1819 A.D.*

This earthquake killed over 1500 people (Richter 1958) and maximum MM scale intensity X+ was observed at Rann of Kutch. The Rann area is close to sea level with salt-impregnated sand and silt. In this earthquake a dramatic land level changes occurred with the rise of Allah Bund (dam of God). Allah Bund extends 80 to 100 km in an approximately E-W direction with greatest height of 6.2m (Oldham 1883, 1926). Chung and Gao (1995) have estimated its moment magnitude as 7.8 and found to be more like reverse faulting event.

(d) *Shillong Plateau, India earthquakes of 1897*

This is a significant earthquake because many new observations of earthquakes were obtained. Oldham (1899) identified on seismograms three types of waves which were predicted theoretically till that time. With this earthquake, at a number of places the stream beds were tilted resulting in changing their course. The Chedrang fault was located about 160 km to the WNW of Shillong and it runs along NNW-SSE direction (Richter 1958). This fault had vertical displacement in which the western portion moved upward, the maximum throw being about 10.5 m in an extent of about 19.2 km. There are conflicting results on the extent of the rupture of this earthquake, but there is general consensus that this earthquake probably involved largely through thrust faulting (Oldham 1899, Khatri *et al.* 1983, Molnar 1987). In this earthquake over 1500 people were killed and almost total destruction of all brick and stone buildings in and around Shillong plateau occurred, such as at Shillong, Sylhet, Goalpara, Gauhati, Dhubri and Tura. The maximum MM scale intensity was XI. Although the magnitude of this earthquake has been assessed as 8.7 (Richter 1958), Abe (1994) reported its magnitude (MS) as 8.0 from the records of 11 observatories.

5. Conclusions

Table 2 gives a compiled list of historical earthquakes of magnitude 6 and above upto 1900. It is felt that the methodology followed in this work by utilising hitherto available reports on earthquakes could be immensely useful to develop a comprehensive historical catalogue of earthquakes in India and its neighbourhood. It is important to note that the magnitudes assigned in the work may have error of about $\pm$ 0.5 units and this aspect may be kept in view while estimating earthquake hazard based on the present catalogue.

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