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A note on the Coimbatore Earthquake of 8 February 1900

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ABSTRACT. An earthquake of moderate intensity at its origin occurred near Coimbatore on 8 February 1900 and was widely felt over south India. It has been determined that the earthquake had a magnitude of the order of 6 and depth of 70 km. The earthquake is significant because of the fact that in south India we rarely get earthquakes of such depth.

1. Introduction

An earthquake of appreciable intensity rocked almost the whole area below Lat. 14°N in south India at about 3-10 A.M. on 8 February 1900. Reports of damage as well as of peculiar experience of the people to whom earthquakes are relatively a novelty poured to newspaper offices from various parts of south India. *The Hindu* from Madras has preserved copies of the papers containing these reports and these were very kindly supplied to the author by the above paper. Table 1 gives a summary of these reports. It will be seen from Table 1 that the southwest Peninsula suffered the maximum damage. These reports as well as a few others received from meteorological observers have been utilised for drawing an isoseismal map which is reproduced in Fig. 1. The intensities are given in Modified Mercalli Scale. It will be seen from the isoseismal map that the maximum intensity occurred near about Coonoor and Coimbatore, indicating thereby that the epicentre was close to these places. The shock was felt over an area of 96,000 sq. miles.

2. Earlier history

The Deccan Plateau is supposed to be a stable region where earthquakes of any significance do not normally occur. This is mainly because the Peninsula represents a stable block of the earth's crust which has remained unaffected since practically the close of Precambrian era. Reports of slight tremors are, however, received from different parts of the Peninsula from time to time. In most of these cases, there has been practically no significant damage to any structure or loss of human life. Geologists have attributed the causes of these tremors to minor crustal readjustments during which process release of energy is so negligible that on many occasions these tremors are not recorded by seismographs operating even a few hundred miles away.

Nevertheless the Peninsula has at times exhibited seismic activity which has been responsible for causing some damage to structures. A list of such earthquakes prior to 1900 A. D. compiled by Milne (1911) and others is given below—

	Date	Epicentral area
1	1341	Malabar Coast
2	1618 (26 May)	Bombay
3	1822 (29 Jan)	Madras, Chittore, Vellore
4	1843 (1 Apr)	Bellary
5	1856 (25 Dec)	Bombay, Surat
6	1881 (31 Dec)	Indian Peninsula, Bay of Bengal
7	1882 (Jan or Feb)	Trincomalle, Ceylon

The first of these earthquakes occurred near the West Coast of India and was, according to Ballore (1904), a very severe one, as a consequence of which the Wayapi Island

TABLE 1

Station	Time when felt (L.T.)	Duration	Direction reported	Important features and summary of the report	Intensity in M.M. Scale
Udipi 13°20′N,74°45′E	3-15 A.M.	—	—	No damage—Thank God	IV
Calicut 11°10′N,75°45′E	3-10 A.M.	2 min.	—	Inhabitants were startled in their beds by the shock	V
Chittore 13°10′N,79°05′E	Between 3 to 4 P.M.	Over 2 min.	—	Slight earthquake—No damage	IV
Chidambaram 11°20′N,79°40′E	3-00 A.M.	—	N to S	We felt an earthquake shock—Appears to have passed from N-S	IV
Karur 10°55′N,78°00′E	3-00 A.M.	2 or 3 min.	—	There was no serious damage	V
Arni 12°40′N,79°15′E	3-00 A.M.	A few sec.	—	Shaking of the houses was fearful.	IV
Kaduba 11°40′N,77°45′E	4-00 A.M.	A min. or two	—	A strong earthquake—No harm to life or property	IV
Ambasamudram 8°40′N,77°45′E	3-00 A.M.	A min. or two	—	A slight tremor with great noise was felt here and in adjacent villages	IV
Tirupur 11°35′N,77°35′E	3-00 A.M.	About 10 min.	—	Heavy shock felt all around. People were greatly alarmed but there was no danger. Slight cracks were caused	V
Trichinopoly 10°45′N,78°40′E	3-00 A.M.	A min. or two	—	Slight shock was felt here and in Srirangam. No damage	IV
Panrutti 11°45′N,79°30′E	—	—	—	Earth began to shake with a tremendous noise all of a sudden. Quaking came to a dead stop suddenly as it began. Many thatched roofs and other immaterial buildings in the vicinity fell down	VI
Ettayapuram 9°05′N,77°55′E	3-00 A.M.	12 or 15 sec.	—	Rumbling noise as the passing of a train of carriages. Things on the table shook; whole room appeared to shake	V
Conjeevaram 12°50′N,79°40′E	3-05 A.M.	½ min.	—	Gentle shock—No accident beyond a rude shake to snoring sleepers : Rattling of doors and windows	IV
Erode 11°20′N, 77°40′E	Between 3 to 4 A.M.	4 min.	E to SW	Very perceptible shock—No loss to life or damage to houses.	IV
Polur 13°50′N,79°45′E	3-15 A.M.	1 min.	—	Sharp earthquake preceded by rumbling noise in the interior of earth. Felt in neighbouring hill areas. No damage	IV
Gannapati-Aghraham Tanjore 11°05′N,77°30′E	2-30 A.M.	A few sec.	—	No damage. Whole village was astir for quarter of an hour	IV
Vriddachalam 11°30′N,79°15′E	2-55 A.M.	10-12 sec.	NE to SW	Vivid and pretty strong shock: Whole town was astir—Respectable old people say that they never felt such hard shock before this	IV
Kuppam 12°00′N,79°00′E	3-10 A.M.	—	—	Almost all the inhabitants were roused from their sleep as if by an electric shock—Pointsman not being able to hold his point straight from 3-06 to 3-10 A.M. Block bells of the signalling key chanted harmoniously—'Cling, Cling' a number of times during this brief space of time. Alarm bell in the Zamindar's compound rang of its own accord.	VI

TABLE 1 (*contd*)

Station	Time when felt (L.T.)	Duration	Direction reported	Important features and summary of the report	Intensity in M.M. Scale
Coonoor 11°20′N,76°45′E	3-10 A.M.	1 min.	—	Severe shock; felt for a good many miles round; beds rocked, walls and roofs trembled; many of the inmates rushed out of their houses; reported fall of tiles from some houses, and falling of furniture here and there; On Nilgiri Railway a boulder has fallen on the line. Many houses—Coonoor Railway Refreshment room, the Chief Commissioner's Bungalow cracked.	VII
Perur durai 9°35′N,76°55′E	3-00 A.M.	3 min.	NW to E	A rumbling noise was heard proceeding from NW; in about half a minute noise increased to a frightful degree and then the shaking commenced. In the beginning shaking was gentle, and in half a minute the shaking increased to a fearful extent. Tiled roofs of houses began to rattle, furniture began to shake—people got terribly alarmed, went out of their houses—Felt in surrounding villages.	VI
Mysore City 12°15′N,76°40′E	3-00 A.M.	1 min.	S to N	Most of the slumberers woke by the prolonged shake. Those sleeping east to west were thrown off or rolled themselves two feet away. Glass tumblers and domestic utensils fell from the cupboards, cooking pots dropped from the kitchen, door shook and window shutters creaked with great noise. Rumbling noise of gun-shot was heard. Tiled roofs got their tiles displaced. Resting cattle stood up and became uneasy. People were astonished at the experience.	VI
Coimbatore 10°55′N,76°58′E	3-10 A.M.	2 or 3 min.	NE to SW	A sudden and fearful earthquake; Roaring noise continued for 2 or 3 minutes, whole inhabitants left their houses. In the suburbs many houses received serious injury—terraced; storied houses getting cracked—Tiles of houses having been displaced. Jail-building fared worse—After shocks felt six times till 5 A. M.—Roman Catholic Chapel rear the Railway Station has given way in a prominent part—No one house could be seen without a clod of mud having been heaped up both inside and outside by the un-roofing of the houses and undermining of the wall and weak parts: A boy was taken out of cover of mud, which had fallen on him by the fall of wall.	VII
Madura 9°50′N,78°05′E	3-07 A.M.	1 min.	—	Vibration about one minute	IV
Nagapattam 10°45′N,79°50′E	3-05 A.M.	A few sec.	—	A slight shock was experienced	III
Bangalore 12°55′N,77°40′E	3-10 A.M.	—	—	Sharp earthquake felt	III or IV
Bombay 18°55′N,72°45′E	21-51·2 GMT	—	—	Shock perceptible in Bombay	I
Kodaikanal 10°10′N,77°25′E	3-15 A.M.	—	—	Felt quite appreciably; everybody awakened	V

was raised above the sea level. The earthquake of 1 April 1843 has been considered by seismologists to be the severest in the region. From the description of damage etc of the earthquake of 8 February 1900 as given in Table 1, it appears that the magnitude of this earthquake was comparable to the Bellary earthquake of 1843.

3. Epicentre

The conventional methods for determination of epicentre, origin time etc, could not be adopted in the determination of epicentre for this earthquake because the only instrumental data that could be obtained for this shock were from the records of the Colaba Observatory where an old Milne-type seismograph was operating at the time. This instrument recorded the first impulse of the shock at 21 hrs 51·2 min. GMT of 7 February 1900. The Bombay Volume for the year mentions that the shock was perceptible in Bombay. But from the size of the shock it seems improbable that the shock could have been felt in Bombay. This is also supported by the fact that no other felt report from places located between Udipi and Bombay was available.

The epicentre of the earthquake has been fixed at Latitude 10°45′N and Longitude 76° 45′E from the isoseismals drawn on M.M. Scale on the basis of the available macroseismic reports. This place lies on a great discontinuity between the Archean Groups and the Coastal Tertiary and the Pleistocene Groups. It is quite possible that the earthquake occurred along this fault zone.

Gutenberg (1956) in his study of 'Great Earthquakes between the period 1896-1903' has observed that the magnification of Milne's instrument was frequently too low to record the P phases and consequently the earliest reported time often refers to S or even a later phase. In this particular case also, the recording of the first phase at Colaba seems to be of some phase later than S. The maximum amplitude was recorded 12 seconds after the first phase, with a trace amplitude of 0·9 mm only. Taking the magnification of Milne's instrument as 5, as suggested by Gutenberg, the ground movement at Bombay must not have exceeded 0·18 mm. In effect this value appears to be too high.

4. Depth of Focus

The wide area over which the shock was felt indicates that the origin of disturbance was not shallow. In the absence of sufficient instrumental data, there is no other alternative but to take recourse to the method of calculation of depth from macroseismic evidence. The following empirical formula has been given by Gutenberg and Richter (1942) connecting the radius of perceptibility r, the maximum intensity I_0 in M. M. Scale and the focal depth h —

$$\frac{r}{h} = \left[10^{I_0/3 - \frac{1}{2}} - 1 \right]^{\frac{1}{2}} \qquad (1)$$

Macroseismic reports indicate a radius of perceptibility of 500 km for this shock. Since the value of I_0 was only 7, the focal depth h according to the above formula came out to be about 70 km. It is difficult to comment on the accuracy of this value but it shows definitely that the depth of focus was considerably greater than obtained for most of normal earthquakes occurring in this region.

5. Magnitude

Gutenberg and Richter (1942) have observed that for shocks of a given depth in any region, there should be a functional relationship between the magnitude M and the maximum acceleration a_0 and have suggested the following empirical formula—

$$M = 2\cdot2 + 1\cdot8 \log a_0 \qquad (2)$$

They have also given the following relation between the maximum intensity I_0 and the maximum acceleration a_0—

$$\log a_0 = I_0/3 - \tfrac{1}{2} \qquad (3)$$

Combining (2) and (3) we get

$$M = 1\cdot3 + 0\cdot6\, I_0$$

As the maximum intensity reached at the epicentre was 7 on M. M. Scale, we get the

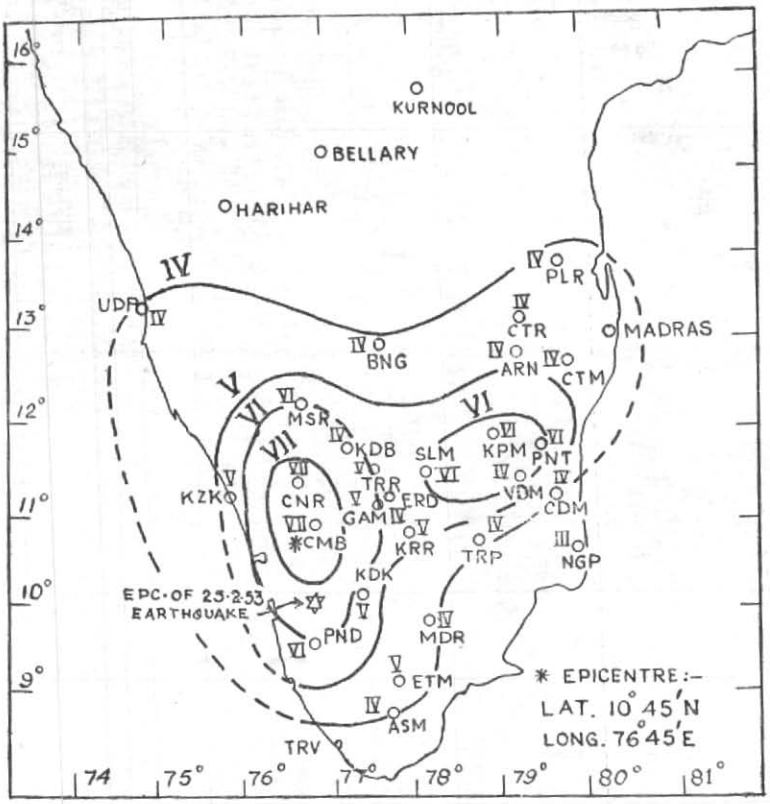

Fig. 1. Isoseismal (M.M. Scale) of earthquake of 8 February 1900

value of M as 5·5. The formulae given above hold good for shocks of normal focal depth (about 15 km). Since the focal depth in this case appears to be more than the normal, this value sets the lower limit of the magnitude.

According to Vit Karnic (1961), the average formula connecting magnitude (M), intensity (I_0) at the epicentre and depth of focus h for European shocks is—

$$M = 0{\cdot}67\, I_0 + 1{\cdot}7 \log h - 1{\cdot}4 \qquad (5)$$

Substituting the values of I_0 and h estimated for the shock, we get $M = 6{\cdot}4$. It is, therefore, concluded that the magnitude of the shock was of the order of 6.

6. Discussion

It has been stated earlier that the Peninsula normally experiences slight tremors due to minor crustal readjustments. The earthquake discussed in this note figures among those few shocks which have been responsible for causing some damage in the southern Peninsula.

From the alignment of the isoseismals it appears that the fault along which dislocation took place had a strike in the direction NNW to SSW. This fact is in agreement with the view expressed by some geologists (Krishnan 1956) that some of the faults parallel to the West Coast and striking NNW to SSW have not yet completely attained equilibrium. Tandon (1959) in his study on the Rann of Cutch earthquake of 21 July 1956, had also stated that the isoseismal map had shown elongation in some particular direction which represented the strike of fault.

According to Byerly, the irregularity in the isoseismal map is the most interesting

feature. Irregularities point to the existence of regions of different geological foundations. This explains the reason of getting a few places experiencing intensity IV or V near the line of isoseismal VI.

The isoseismal map shows two areas bounded by intensity VI, showing thereby two zones of weakness. In the absence of detailed seismic data, it is difficult to explain the existence of the second zone which could perhaps be due to a secondary focus. It is also possible that the formation of the second zone is due to the existence of particularly weak strata.

Although the maximum intensity reached both in the case of Bellary earthquake of 1843 as well as in the earthquake of 1900 (under discussion) was VII on M. M. Scale, yet the area of perceptibility was much less in the case of Bellary earthquake than that of the earthquake under discussion. This fact shows that the depth of focus in this earthquake was much larger than in the Bellary earthquake.

As mentioned earlier, earthquakes in Peninsular India are rare. A few earthquakes which have been studied in some detail reveal a depth of focus not far from normal. It seems, therefore, interesting to note that earthquake shocks having a focus as deep as 70 km can also occur in this region. A detailed study with the help of network of seismographs in this region may reveal many facts which may be of much interest to seismologists and geologists alike.

7. Acknowledgement

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