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Summary. One of several pre 20th century earthquakes in the central gap of the Himalaya occurred in 1833. Hitherto its location and magnitude were not well known. Newspaper accounts and official documents report the felt effects of the event and a magnitude of M7.7 has been assigned to it. Its location is apparently in northern central Nepal. Since publication, the location of the garrison town of Mullye has been identified on Thomson's New General Atlas of 1817. Mullye lies due south of Kathmandu at 27°N, 85°E, approximately 15 km NE of Bettiah near Raxaul.

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Location and Magnitude of the 1833 Nepal Earthquake and its Relation to the Rupture zones of Contiguous Great Himalayan earthquakes

Roger Bilham CIRES and University of Colorado, Boulder CO, 80309-0216

Abstract: Accounts of an earthquake on 26 August 1833 which was felt over a large part of northern India have been interpreted by some authors to represent a great Himalayan thrust event beneath Western Nepal. However, details of the event in the Indian press of 1833 and scientific journals of that time, suggest that the epicenter of the earthquake was near Kathmandu within, or close to, the inferred rupture zone of the Bihar 1934 earthquake. Estimates of moment magnitude based on reported intensities indicate that the earthquake was $7.5 < M < 7.9$, and as such may have done little to release elastic strain accumulating in the region of the Central Himalayan seismic gap, contrary to the expectation of some authors. The location of the epicenter was probably N or NE of Kathmandu, adjoining or overlapping the rupture area of the great 1934 Bihar/Nepal earthquake. The Moment Magnitudes of great Himalayan earthquakes in 1897, 1905, 1934 and 1950, and smaller recent events are compared using recently published empirical relations between isoseismal areas and moment magnitude (Johnston, 1994). When due allowance is made for deficiencies in field data, reasonable fits are obtained for all events except for the 1905 Kangra earthquake. The intensity VIII area for this event is anomalously small for an M 8 earthquake associated with several meters of slip. It is proposed that the Kangra earthquake may have been a slow earthquake.

Introduction

Approximately half of the Himalayan arc has ruptured in four great earthquakes in the past 100 years (Figure 1). The largest region between the rupture zones of these recent events is a 500-800 km segment of the Himalaya between the 1905 Kangra and the 1934 Bihar earthquakes, approximately between the longitudes of Kathmandu and Delhi. Of importance in estimating the present slip potential of this segment, termed the Central Gap by Khattri and Tyagi (1983), is the existence and severity of great historic earthquakes that may have ruptured all or part of the gap. A severe earthquake occurred in Nepal in 1255 when "innumerable towns were utterly destroyed and thousands of their inhabitants killed" (Campbell, December 1833) but the regional extent of this event is unknown. Other large pre-XX century earthquakes in Nepal (1408, 1681, 1810, 1833, and 1866) are mentioned by Chitrakar and Pandey (1986) but none appear to have been as damaging as the 13th century event, causing concern that considerable elastic strain may be available presently to drive one or several $M > 8$ earthquakes in the Central Gap.

An alternative mechanism to absorb slip between Tibet and India is to invoke the possibility of aseismic slip (slow earthquakes or creep) over at least part of the region. Leveling data and recent GPS measurements between India and central Nepal (Jackson and Bilham, 1994; Bürgmann et al., 1994) suggest that creep processes that might otherwise release Indo-Asian convergence aseismically have been insignificant in the past few years. If similar creep rates (2.5 ± 2.5 mm/year) exist elsewhere along the arc throughout the seismic cycle they are evidently inadequate to accommodate completely the slip budget between India and southern Tibet, although they may delay rupture (Bilham et al., 1995). The possibility that some Himalayan earthquakes may be slow events, with large slip but little radiated high-frequency seismic energy, cannot be excluded (Sacks and Linde, 1981; Beroza and Jordan, 1990). Such events would

not appear in the historical record as great earthquakes although they could, in principal, release the elastic strain associated with one.

Earthquakes in 1803, 1833 and 1866 appear to have occurred at least partly within the central gap (Khattari, 1987) and the largest of these in terms of felt area is believed to be the 1833 event. Reports of the 1833 earthquake are found in newspapers starting the day after the earthquake, and these and other data are collated in three issues of the Journal of the Asiatic Society of Bengal in the months following the earthquake by Prinsep (1833) and Campbell (1833), and by Baird Smith in two articles a decade later (1843,1844). Summaries of these summaries are found subsequently in various catalogs and comparative studies: Mallet 1852, 1855; T. Oldham 1883; R. D. Oldham, 1897; Dunn et al. 1939; Bapat et al, 1983 and Dunbar et al. 1990. The compilation by Dunbar et al. 1990, lists the event as severe and records its location as 25.1 N and 85.3 E , near Patna south of the River Ganges, at the southern limit of intense shaking described in 1833 reports. A location west of Kathmandu is favored by some authors (Seeber and Armbruster, 1981) who suggest tentatively that it may have occurred in the Central Himalayan Gap. Khattri and Tyagi (1983) place the earthquake approximately 130 km west of the Bihar 1934 epicenter on the edges of the Central Gap and assign the event $M=7.6$, a location and magnitude consistent with the findings of the present study. One purpose of this article is to estimate more precisely the location and magnitude of the 1833 Nepal earthquake using authentic accounts found in newspapers and scientific articles published soon after its occurrence. A second purpose of the article is to reconcile the intensity data from the 1833 earthquake with the felt reports of four great Himalayan earthquakes and other earthquakes that have occurred since then.

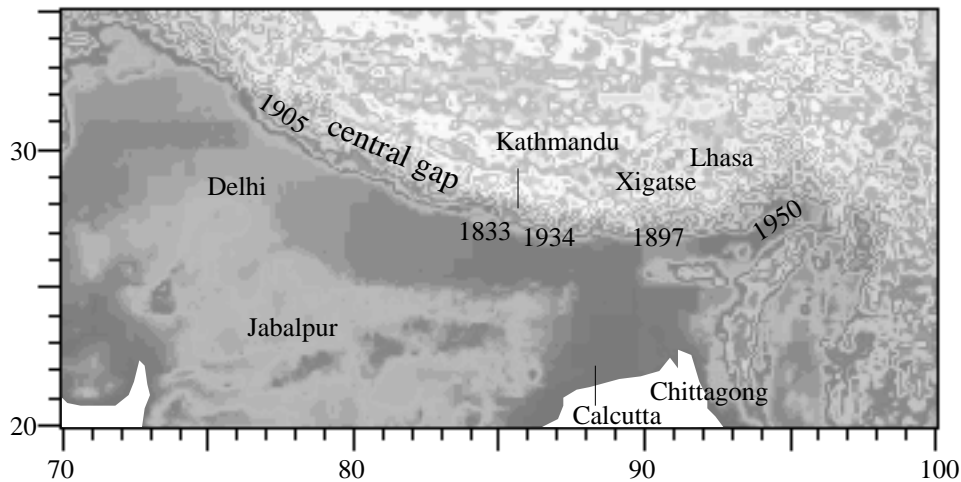


Fig. 1 Approximate Modified Mercalli Intensity VIII zones for 5 large earthquakes in the Himalaya since 1833 and settlements reporting information concerning the 1833 shock (white dots). A great earthquake may not have occurred in the 800 km segment of the Himalaya between the 1905 Kangra and 1934 Bihar earthquakes (Central Gap) for 650 years.

The 1833 earthquake

Just before midnight on 26 August 1833 (23:35 Calcutta time) a 1 million km² region of northern India, Nepal and Tibet was shaken by a strong earthquake which, triggered landslides and rockfalls, destroyed more than 4600 dwellings and many temples, but apparently resulted in fewer than 500 fatalities. It is certain that the loss of life would have been far more severe had not the mainshock been preceded by two large foreshocks five hours and 15 minutes before the mainshock that drove people outdoors in alarm. In some villages in northern Nepal and southern Tibet 30% or more houses were destroyed. Damage in India was less severe with fewer than 10 reported fatalities and few buildings totally destroyed.

The mainshock was felt from Delhi to Chittagong (Fig. 1). It was not felt in Lhasa nor are there reports of the shock further SSW than Jabalpur. Intensities were high in the mountainous region near and north of Kathmandu, and reduced rapidly to the south and more slowly to the east and west. Intensities remain high

at the northern limit of high intensity observations in southern Tibet. Accounts of damage where shaking was most intense suggest a similar intensity distribution to that observed during the Bihar 1934 earthquake with the principal exception that accounts of liquefaction features in 1833 are rare. Passes to Tibet were blocked by landslides, and the Kamla River was dammed by a landslide that burst 4 days after the event flooding the village of Baldeah near the India/Nepal border (Bengal Hurkaru, 16 Sept. 1833).

Isoseismal Coverage and Accuracy

The fidelity with which Indian newspapers reported effects of the 1833 earthquake can be gauged by the faithful reprinting of articles printed in one by another. More than a dozen newspapers, and weekly and monthly journals were published in Calcutta (The Reformer, Calcutta, 3, 141, Oct. 27, 1833) although not all of them reported news of the event, and a few are no longer available. Newspapers in Delhi, Bombay, Meerut and Madras also contain accounts of the earthquake. In the 52 accounts in the Appendix, 97 towns and villages are mentioned. Most of these reports can be assigned Modified Mercalli Intensities V-IX with reasonable certainty. Few “barely felt” reports are available and fewer “not felt” reports (e.g. Nazirabad, Xigatse and Lhasa), and the general sparsity of intensity IV or smaller observations prevents reliable estimates of those areas that experienced the earthquake weakly. The absence of details of construction methods of those houses destroyed, or of those surviving, means that intensity estimates are not as reliable as those for the 1934 earthquake (Dunn et al. 1939), and although it is likely that construction practices changed little between the two earthquakes, it is certain that urban dwelling units and civic buildings were less numerous in 1833. This may influence comparisons between the 1833 and 1934 earthquakes because several damage reports are from urban regions near factories or administrative centers for both earthquakes. The Gangetic Plain except for the Kingdom of Oudh, south of western Nepal, was under British colonial rule in 1833 (Walker, 1833). However, reports from Oudh are available despite a significant cholera epidemic in Lucknow and Allahabad. With perhaps the single exception of data from Monghyr (Monger) most of the reports contributed to Indian newspapers are in the form of personal accounts of the earthquake with no statistical descriptions of urban damage. Few fatalities are reported: three during the mainshock at Chapra and one for an aftershock in Bhagalpur. In some accounts additional fatalities are implied although it is probable that the low loss of life was real, and is attributable to the second foreshock that evidently drew people into the safety of the open air fewer than 15 minutes before the mainshock.

In contrast to the anonymous accounts in Indian newspapers, Archibald Campbell, an assistant surgeon to the British Residency in Kathmandu, in three contributions to the Asiatic Society of Bengal (Prinsep, August 1833; Campbell, November and December 1833) compiled unofficial numerical damage and casualty data from the Kathmandu Valley, from travelers returning along the Kodari route from southern Tibet (passing through Dulka, the northern Nepalese border district of Dolakha), and from the official delegation returning from Lhasa through southern Tibet. He also mentions damage to forts along the southern trading route from India (Hetauda, Chisapani). Although he also obtained information from western and east-central Nepal his sources of information from these regions are not cited and data from these regions may be less reliable. Thus, unlike data from N and NE Nepal which mention specific towns and villages, his information from western Nepal refers to regional administrative areas. “At Gorkha (75km E of Kathmandu), only two houses were destroyed; at Palpa (180 km E of Kathmandu) none; and at Doti (540 km W of Kathmandu in westernmost Nepal), on the borders of Kumaon, the shock was felt, but by no means severely”. Although this westward decay in intensity over several hundred km is unsupported by details it is consistent with the decay in intensity documented independently in northern India. For example, Baird-Smith (1843 p.1051) reports “it was scarcely felt at all” at Lohughat (=Lohu Ghar, 29°23’N, 80°05’E, 18 km from the E. Nepal border). Campbell (1833) also emphasizes that the shock was not felt in Lhasa nor Xigatse, contrary to Mallet (1855, 238-240) and Dunn et al. (1939 p.116), who repeat early speculation by Prinsep (1833). In a following issue Prinsep, as editor of the Asiatic Society journal, corrected his erroneous guess that Lhasa was close to the epicenter (Campbell, 1833) but not until it had been repeated in Calcutta newspapers (e.g. India Gazette, Oct. 6 1833).

In general terms, information concerning the 1833 earthquake in northern India is restricted to British trading posts, and information from Nepal and Tibet appears to be restricted to the Kathmandu Valley and to villages on merchant routes from Kathmandu to Tibet and to India (Figure 3).

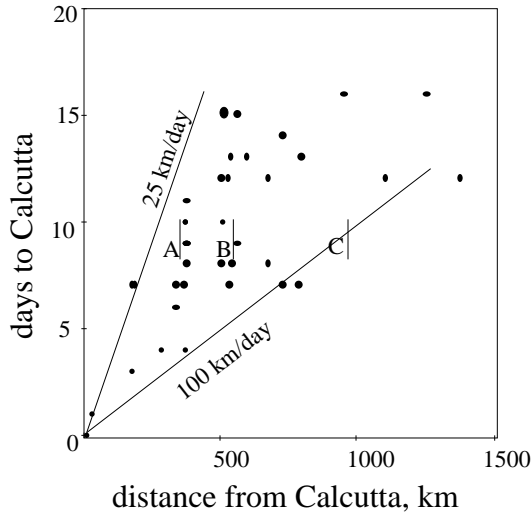


Fig. 2 Delay between mailing a letter and its arrival in Calcutta assuming publication occurs the day following its arrival. The three vertical lines indicate possible locations for Mullye. A=Murliganj, B=Manjhi and C=Malihabad or Malloon. The Vedic district of Malla lies between B and C. Distances are geodesic. The most remote point on the graph from Calcutta is Delhi.

Location names

Place names in India are readily matched with current locations for all but three 1833 listed localities: Tirhoot, Mullye (Mallai of Prinsep, 1833) and Baldeah. The first of these corresponds to the district of Tirhoot south of Nepal named after the town of that name now Muzaffarpur (District Map of India, 1840, 64 mi=1”), however, it is not clear that

the three damage reports from Tirhoot came from Muzaffarpur or from villages between Muzaffarpur and the Nepal border (Motihari, Sitamarhi, Darbhanga etc.). Despite the absence of specific locations, the high intensity shaking reported from Tirhoot unquestionably identifies a region in the southern Terai of Nepal or northern plains of India.

Mullye has eluded identification¹ with either a district or town, and in this case the absence of a precise match is regrettable because from this region comes one of the two comparisons of the 1833 event with the 1803 Kumaun earthquake (the other account from a resident in Calcutta recalling the occurrence of a severe earthquake during the siege of Aligarh (27°55'N, 78°10'E) soon after the start of the second Anglo/Maratta war). The approximate location of Mullye is revealed by the fact that Calcutta news reports from Mullye took 9-11 days between mailing and publication. An additional clue is that a summary of the affects of the event south of 26°N from a correspondent in Agra omits mention of Mullye suggesting that it lies to the north of 26°N. Robert Mallet, who in 1851 discusses the 1833 earthquake as the 1834 Nepal earthquake (Mallet, 1852 p.313) places “Mallai?” on a travel time map of India (ibid. Plate XVII) at approximately 22.9°N, 91.2°E (Maijdi), yet the inferred intensities are too high, and the reported sun-clock times of the mainshock too early, for this location. He corrects the date to 1833 in his report of 1854 (Mallet, 1855, p.238). A graph of news travel times to Calcutta (**Figure 2**) shows that an westward location for Mullye could correspond to the Vedic district of Malla, approximately between Gorackpur and Chapra, but this term is unlikely to have been in common use in the 19th century. Of towns and trading centers in the region, Mullye is considered a possible abbreviation for Malihabad or Malloon (Walker, 1833) near Lucknow, Manjhi (25°40'N, 84°30'E) near Chapra, or Murliganj (25°42'N, 86°59'E) near Purnia. Malihabad is evidently too far from Calcutta for normal 9 day news delivery, requiring travel times exceeding 120 km/day. Although the remaining suggested locations are at the correct range for news delays of 9-11 days, the phonetic resemblances are poor. In the absence of certain identification the three intensity V reports from Mullye are omitted from the isoseismal map.

It has not been possible to identify the precise location of Baldeah on the Kamla River where a flash flood followed the breaching of a temporary-lake dammed by an earthquake-triggered landslide. From the description (appendix) it is likely that this was near the Nepal border at longitude 86°08'.

Place names with phonetic similarity and geographic proximity to indicated regions have been identified for most of the villages in the Kathmandu Valley, and where these are questionable they have been

¹ As noted in the introduction to this PDF file, Mullye has been located since publication on Thompson's 1817 Atlas. The following entry in Hunter's Imperial Gazetteer clarifies its location : "Mallái (also known as Majorganj and Halakhaura). Market town in Muzafferpur ditrict, Bengal 26°45' N, 85°28.5'E on the main road from Maniárigat to Sonbarsa. Site of British cantonment during the Nepalese war of 1814. pop. (1872) 1425." W.W. Hunter, Imperial Gazetteer of India, Vol.VI. pp531. Trübner London 1881

identified in Table 1. Although relatively few locations outside the Kathmandu Valley are mentioned by Campbell, they are important in identifying shaking intensity to the north and east.

Campbell's latitude for Tingri (28°N) is approximately 60 km too far south suggesting that he did not have good maps of southern Tibet. Rennell's map of 1782 showing Tingri at 29.3°N, was known to be in error to the British Residency in Kathmandu in 1801 but new maps prepared by Crawford in 1803 of the route to Dugurcheh (Xigatze) were very incomplete (Phillimore, 1950, p.71). Rennell's map is of interest because it shows Nesty, Dunna, Kansa, Chuska, Kut or Kutí, and Mescingzhung in sequence northward toward Tingri, over the mountain pass between Nepal and Tibet near the present border village of Kodari. The spacing of villages suggests that each interval represents a day's march. Nesty appears to correspond to Nisti, and the old fort at Dugunna Garhi may correspond to Dunna. Kansa is the village of Dram (Khasi in Tibet), 5 km NE and 400 m above Kodari corresponding to Kassa mentioned by Campbell (Nov. 1833) without explicit damage reports. Chuska of Rennell's map may correspond to Choksum (28.07E, 86.00N) or Kan Sing Chok (Campbell 1833). The location of Kuti mentioned several times by Campbell is the Tibetan name for Nyalam (D. Bresheares, personal communication 1994). At least two of the five villages mentioned as on the "Bhote or eastern pass to Tibet" (Nan Sing Chock, Kuti, Kassa, Mundun Pahar and Listigoan) appear to correspond to villages in a 20 km NS region of intense shaking that includes the present border village of Kodari, and it appears possible that information from a region within a quarter of a degree of 27°N, 28°E was conveyed by travelers returning from Tingri to Kathmandu along this trading route.

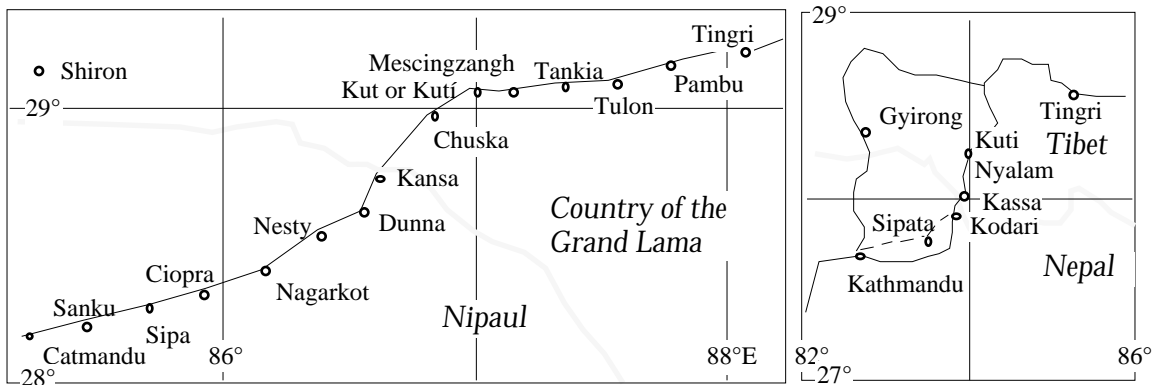


Fig. 3 Villages between Kathmandu and Tingri through the Kuti Pass (Rennell, 1782). Figure on right shows the true coordinate locations for Kathmandu, Tingri, Gyirong, inferred locations for Kassa, Sipa, Kuti, and merchant routes to India and Tibet.

Rennell's map also shows the village of Sipa (Campbell's village of Shipa, 32 km east of Kathmandu) on the Kofs (Kosi) River between Sanku (Sankhu, 27°45', 85°28') and Ciopra (?Chautara). Sipa probably corresponds to Sipata or Sipatinghare (27°45', 85°39') on the Indrawatty tributary of the Sun Kosi which lies on the trekking trail to Kodari north of the current Kathmandu-Kodari road. The village of Nagarkot (meaning Snake Hill) on Rennell's map between Ciopra and Nesty does not correspond to the geodetic observatory of that name on the eastern hills overlooking the Kathmandu valley.

The location of places in Campbell's Dec. 1833 account are of particular importance in tracing the felt area to the north and east of Kathmandu. Digarchi is the present Shigatse or Xigatze (29°17', 88°54') and Tingri (28°30', 86°30') retains its old name. However, from Tingri Campbell indicates that a 8-10 day march due-west brought the Nepal/Beijing returning delegation to the village of Kirung. Kyirong or Gyirong (28°33', 85°16', Shiron on Rennell's map) is 180 km W. along the road from Tingri, and although the pass south of Kyirong enters Nepal by the Bhote Kosi, which means "Tibet sacred river" it is only one of several rivers of that name crossing the border, including one through the Kuti pass into Kodari. It is for this reason that Campbell may have been misled into entering in parenthesis that the delegation came through "the eastern pass of the valley into Bhote". The Kyirong route they followed would more appropriately be called the northern pass to Tibet.

Isoseismal map for 1833

Descriptions from the original reports were assigned values on the Modified Mercalli Intensity scale (**Tables 1 and 2 and Appendix**). Where several reports from the same village exist, the intensity data in most cases agree adding confidence to the observations. Moreover, although the intensity data for the 1833 event are somewhat uneven in coverage they yield relatively smooth spatial variations in intensity (**Figure 4**). The intensity data may be interpreted as smooth curves that approximately encircle the appropriate intensity data, or more complex figures that adhere rigorously to mapped intensities. **Figure 4** shows a series of smooth ellipses that approximate the observations. The resulting isoseismals are prejudiced by a preference for simplistic geometry, yet although a number of alternative curves could be constructed they would have the unavoidable characteristic of indicating maximum intensities in east-central Nepal, close to the 1934 epicentral region. A more realistic set of isoseismal curves is considered unwarranted given the distribution of intensity data. As an example of the complexity denied by adopting elliptic isoseismals, the intensity observations from the 1833 earthquake are superimposed on a map of the observed and inferred isoseismals for the 1934 Bihar earthquake. Few of the 1833 intensity data are found outside the corresponding 1934 isoseismals suggesting that similar complexity in local isoseismal geometry may have prevailed in the two events, enforced by basin response characteristics.

An approximate estimate for the felt area of the 1833 earthquake (dashed on **Figure 4**) is found in Oldham's memoir on the 1897 earthquake (Oldham 1899). Oldham does not indicate his sources although it is likely that the data come from his father's chronology of Indian earthquakes (Oldham, 1883), and that the contour shown is meant to represent the area within which the earthquake was perceptible (i.e. Mercalli intensity II). This 0.21×10^6 km² felt area includes Chittagong to the southeast (editorial footnote by Prinsep in Campbell, December 1833, "Mr. Walters informs me that it was also felt in Chittagong"), but omits information from Delhi and other western points, and from Jabalpur to the SW. Using a smooth ellipse to embrace these western points increases the felt area to approximately 1.2×10^6 km². Uncertainty in this estimate is caused largely by the sparcity of data to the SW, E and N. Although the elliptical aspect ratio of the intensity VI isoseismals is favored by the specific absence of felt shaking in Lhasa and Xigatse and by the shape of intensity VII isoseismals, the absence of reports from central India in theory permits the felt radius to increase substantially to the SW. Thus the estimated areas for intensity <V are assumed to err on the low side and estimates for earthquake magnitude presented below are given both for elliptical and circular isoseismals. Intensity I-III isoseismals are omitted from **Figure 4** as no data are available. The largest ellipse drawn for the 1833 earthquake in **Figure 4** corresponds to Mercalli Intensity IV which is presumed to be significantly smaller than the area of felt perceptibility. Reports from locations specifying that the earthquake was not felt are absent except to the NE, and from remote locations such as Bombay and Madras.

Uncertainties in isoseismal area in Table 1 correspond to maximum and minimum estimates for areas contained within the smooth symmetrical contours selected to fit the observations in Figure 4. Although these are apparently uncertain to $\pm 1\%$ based on the mapped isoseismal reports, this figure does not account for errors in estimating the Mercalli Intensity from the eye witness accounts in the Appendix. Variations in building toughness and subjective interpretation of damage may result in errors perhaps an order of magnitude larger. Moreover, from the 1934 (Dunn et al. 1939) and 1988 (Sinha, 1993) Bihar/Nepal events it is clear that that isoseismal contours in the region are typically more complex.

The congruence between 1833 and 1934 intensity data is interesting in that in the few locations that isoseismic intensities disagree they differ by not more than one intensity unit. The 1934 isoseismals shown in **Figure 4** are somewhat uncertain within Nepal since they are formed by merging the isoseismals shown in Dunn et al. (1939) with intensity data discussed by Pandey and Molnar (1988). Although the resulting extension of the intensity >VIII data northward can be justified using the authority of Rana (1934) the position and dimensions of the intensity IX region is conjectural. The centroid of intensity VIII area for the 1833 earthquake is apparently displaced approximately 1 degree to the west of the equivalent region for the 1934 earthquake, consistent with Khattri's 1987 location. This observation is sustained, however, by three observations only: at Goruckpur, Gorkha and at Chapra (Chuprah) on the Ganges. Examination of the first two of these reports shows that intensity VIII data are but weakly supported by the reports. Thus, were the buildings damaged of poor construction, a lower intensity could be assigned to these villages. The 1833 Chapra account describes slumping ("a chasm of considerable depth formed") which may indicate a localized region of high intensity shaking near the Ganges similar to the narrow intensity IX region in 1934. The

inclusion of these westernmost VIII intensities in an elliptical fit to this isoseismal results in an 1833 intensity VIII area similar to the inferred 1934 intensity VIII isoseismal. However, a much smaller region for 1833 intensity VIII is admitted by the data if the same pattern of localized severe shaking occurred as in 1934. For example, the sparsity of intensity VIII data in 1833 between Dhankuta and Dharbanga admits the possibility that the area of intensity VIII shaking could be as low as 60,000 km² or as high as 100000 km², the latter being the inferred area of intensity VIII shaking in 1934.

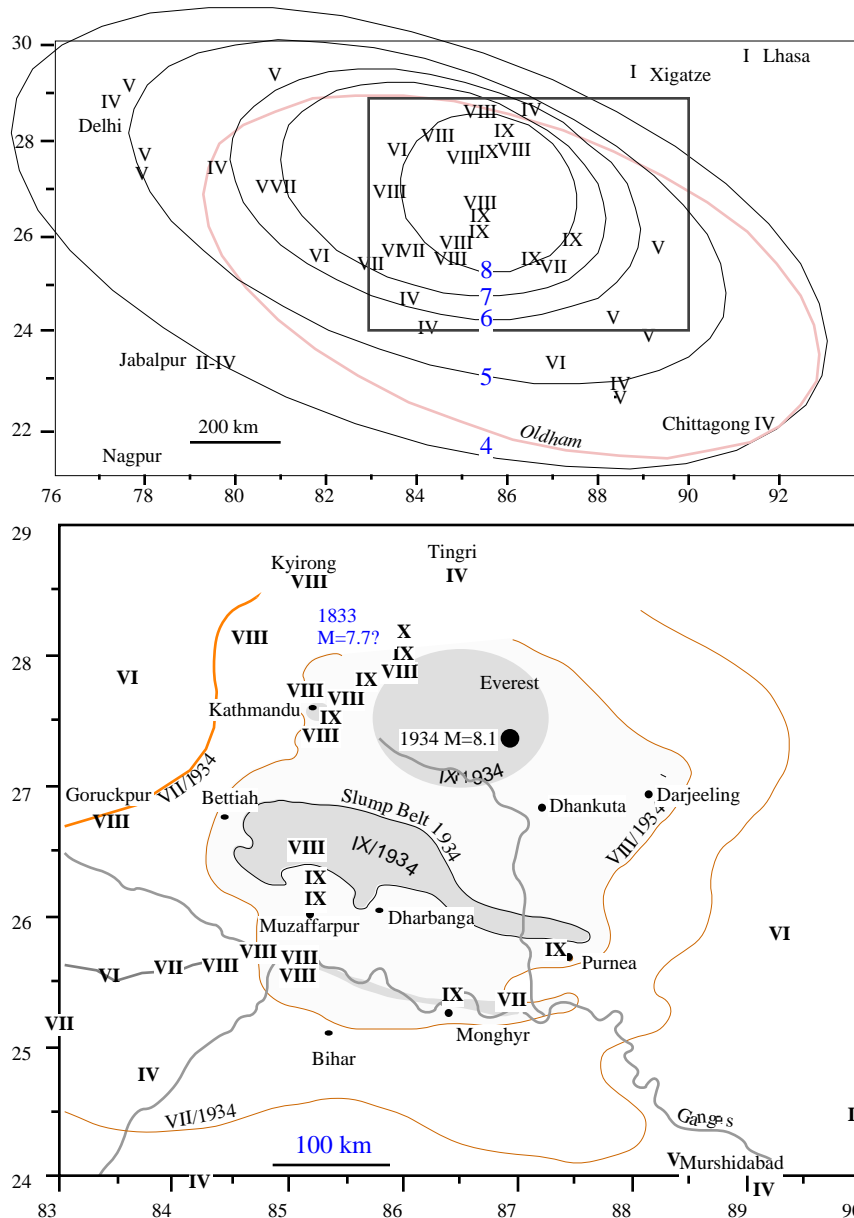


Fig. 4. Intensity reports for the 1833 Nepal earthquake with smooth elliptical isoseismals. In the enlarged view of the epicentral region (inset above) 1833 intensities are superimposed on isoseismals VII-IX for the Bihar 1934 earthquake (modified from Dunn et al. 1939, by incorporating data discussed by Pandey and Molnar, 1990). On both occasions high intensity shaking occurred in the same geographic settings although 1934 isoseismals appear displaced approximately 100 km to the east.. A possible 1833 epicentral location and moment magnitude is indicated.

Three regions of severe damage were reported in the 1833 and 1934 earthquakes, an observation that led Dunn et al. (1939) to note a similarity between the two events: the Kathmandu Valley, a high intensity region near the Ganges including Monghyr, and a region north of Muzaffarpur. Data near the slump belt of 1934, a region of catastrophic lateral spreading, is sparse and although high intensities are recorded near Tirhoot and Purnea (VIII-IX) no liquefaction features are mentioned here in 1833. The area consists of flat lying sediments and ox-bow lakes across which numerous rivers meander. Further south, at Chapra and Monghyr, accounts indicate localized liquefaction near the Ganges, and minor ground damage is reported to the north, near Bhagmati in the Kathmandu Valley. Shaking intensities in the Kathmandu valley were similar for both earthquakes with highest intensities near Patan. Baird-Smith (1843) noted that damaging shaking at Monghyr frequently accompanies large earthquakes, an observation repeated both by Dunn et al. 1939, and by Pandey and Molnar 1988. A favored explanation for localized high intensities in this region is that surface waves are amplified in the water-saturated sediments as they approach the southward shelving bedrock surface south of the Gangetic Plain (ibid, 1988). Similarly, the lake deposits of the Kathmandu valley can be assumed responsible for localized high intensities and rapid variations in intensity in this region as were observed most recently in 1988 (Dikshit and Koirala, 1989).

Magnitude of the 1833 Earthquake

Various empirical relations have been developed to relate felt areas to magnitude (e.g. Topozada, 1975; Hanks and Johnston 1993; Johnston, 1994a). A physical formulation to account for the observed relation between intensity and moment magnitude has been proposed by Frankel (1994) the coefficients of which have been fit to the global data base by Johnston (1994b). I shall refer to this as the F94 model. Moment magnitude, M_o , of an earthquake in the F94 model is related to the area enclosed within a specified isoseismal intensity contour, S , with an expression of the form

$$\log M_o = a + b \log S + c \quad (1)$$

where the constants a , b and c are determined empirically for each isoseismal area. Intensity magnitudes are shown in Table 3 using coefficients derived from worldwide data that include 6 Indian events (Johnston, 1994b). A mean magnitude determined for the 1833 earthquake in this way is 7.5 ± 0.3 , close to the $M=7.6$ adopted by Khattri and Tyagi (1983), however, a monotonic decrease in estimated magnitude with intensity is observed, presumably indicating systematic differences between the global coefficients and those appropriate for the 1833 event. Data for several Indian earthquakes are presented in Figure 6 to illustrate these possible biases. Notwithstanding the ensuing discussion, a cursory inspection of Figure 6 indicates that the 1833 earthquake must be greater than $M=6.6$ and less than $M=8.1$, the inferred magnitudes of the Bihar 1934 and Udaypur 1988 earthquakes.

Table 3 Isoseismal Areas and estimated Moment Magnitudes for the 1833 earthquake.

Constants a , b , and c are from Johnston (1994) for global data least-squares fit to equation (1). Moment magnitudes for elliptical areas (F94e) are from Figure 4, and those for circular areas (F94c) for diameters equal to the long axes of the ellipses in Fig. 4 where unconstrained by data to the SE. Areas are expressed as $\log_{10}(\text{area km}^2)$ and M_o in $\log_{10}(\text{dyne cm})$.

Intensity	felt	IV	V	VI	VII	VIII	mean M_o
a	19.62	18.36	20.44	19.51	22.96	24.3	
b	0.5	0.903	0.607	1.307	0.00307	0.00655	
c	0.00163	0.00206	0.00312	0.00079	0.00307	0.00655	
elliptical area (E)	$6.16 \pm .08$	$5.87 \pm .06$	$5.55 \pm .02$	$5.35 \pm .02$	$5.02 \pm .04$		
$\log(M_o)$ F94E		26.4	26.7	27.2	27.8	28.0	
M_o F94E		6.9 ± 0.2	7.1 ± 0.1	$7.46 \pm .02$	$7.82 \pm .03$	7.9 ± 0.3	$7.5 \pm .3$
circular area(C)	6.42	6.16	5.86				
M_o F94C		7.6	7.9	7.9			$7.8 \pm .2$

Frankel (1994) assumes that attenuation is radially symmetric resulting in circular isoseismals. These are not appropriate for the Himalayan plate boundary. Yet it is not clear whether the observed isoseismal ellipticity is an artifact of reporting, an east-west amplification effect, or a north-south attenuation effect. The elliptical isoseismals inferred in **Figure 4** have an approximate 2:1 aspect ratio with their long axes

parallel to the Himalaya, but as mentioned previously this is possibly biased by the absence of reports to the north and to the SE. By assuming that the lower intensity isoseismals approximate circles with their radii equal to the semi-major axis of the ellipses shown in Figure 4, circular intensity IV, V and VI isoseismals can be invoked that yield intensity magnitudes of 7.6, 7.9 and 7.9 respectively, raising the mean magnitude intensity to $M=7.8$. Although the observations permit this interpretation to the SE, the “not felt” data from Lhasa and Xigatse (Campbell, 1833) are inconsistent with circular isoseismals. Moreover, the elliptical aspect of Himalayan isoseismals appears to be a common feature of Himalayan earthquakes. Intensity VI to VIII isoseismals for the $M=6.6$ Udaypur 20 August 1988 earthquake exhibit an aspect ratio of approximately 4:1 (Pandey and Nicolas, 1989; Dikshit and Koirala, 1989). Isoseismals VI-VIII for the 1991 Uttarkashi earthquake are elongated 2:1 along arc (Thakur and Kumar, 1991) and intensity $>VI$ and VII isoseismals for other Himalayan events show elongation parallel to the arc (e.g. Kangra VII 1905, and Bihar 1934). Thus although the absence of radial symmetry for intensities $>VIII$ could be ascribed to source geometry, it is surely necessary to invoke transmission effects as the reason for the elliptical isoseismal areas VI-VII found in the southern Himalaya and Gangetic Plain. For example, it is likely that the sediments overlying the stable continental crust in the Gangetic Plain act as a wave guide for surface waves traveling east-west with periods of 1-3 s (Banerji, 1953). Similarly, the dipping interface between the Indian plate and the overlying sediments may result in less interference along strike than updip and downdip, favoring along-arc perceptibility. For the lower intensities that are felt south of the Gangetic Plain the intensity distributions for the four great earthquakes between 1897 and 1950 are approximately circular, consistent with transmission within uniform crust.

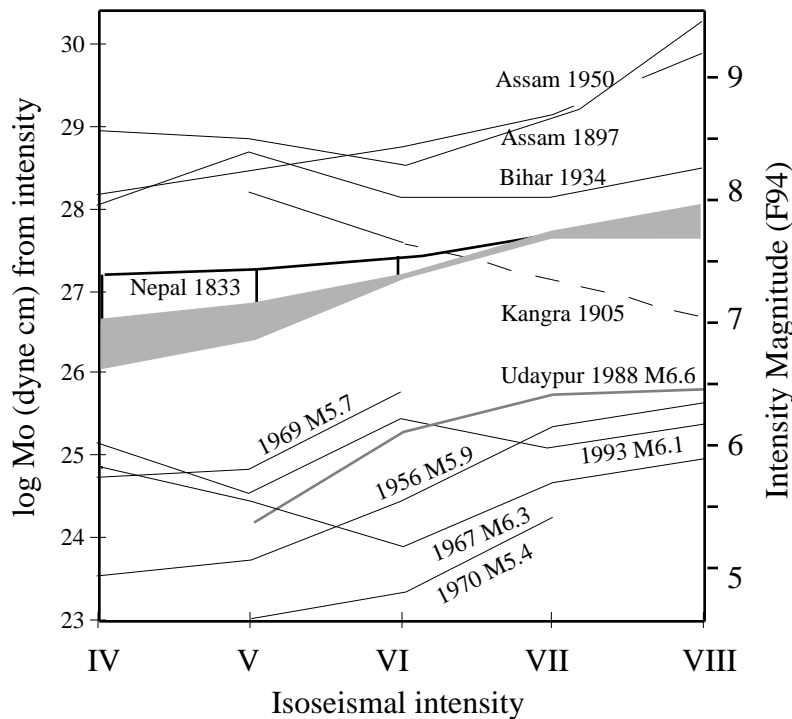


Figure 5 Moment magnitudes inferred from Johnston’s F94 coefficients for several earthquakes in Nepal and India. The shaded area represents the range of magnitudes inferred for the 1833 earthquake using elliptical isoseismals (Fig. 4). The overlying fenced region assumes circular isoseismals (see text). Assam 1897 data from Oldham (1899). Bihar 1934 from Dunn et al. (1939) and Pandey and Molnar (1990). Udaypur; Dikshit and Koirala, (1989); Sinha (1993). Events in tilted script from Johnston (1994).

Epicenter,

Aftershocks and Rupture areas in 1833 and 1934

The location of the mainshock cannot be determined unequivocally from the data presented here. This is largely because most of eastern Nepal and southern Tibet are unrepresented in the felt report data, preventing incontestable closure of isoseismals greater than VIII in these directions. A tantalizing intelligence attributed to “vulgar report” by Campbell (Nov. 1833), is that for 5 days before the earthquake “noises similar to the firing of cannons were heard as if underground: and in this neighborhood” (Kan Sing Choke, possibly Choksum at 86E, 28.07N), “the high road to Lhasa is said in many places to be blocked up by the fallen earth from the mountains”. If these are interpreted as foreshocks close to the epicenter of the mainshock, the epicenter would be placed unreasonably close to a rapid decay in felt intensities eastward. That is, intensities at Tingri 100 km to the NE are estimated at IV, whereas at Kyirong and Kathmandu,

similar distances from Choksum to the NW and SW, intensities exceed intensity VIII. Thus if the mainshock, or one of the foreshocks, occurred near Choksum, this may have been the eastward limit of subsurface rupture. The few aftershocks that were reported in 1833 do not provide any clear idea of the possible rupture zone of the earthquake southward or westward although their widespread manifestation favors a shallow thrust more than a deep focus event such as the 1988 Udaypur earthquake. Continuous ground motion in the days following the 1833 earthquake was claimed at Monghyr, Tirhoot and Kathmandu, the three regions of highest intensity shaking. The concentration of felt aftershocks within these areas may not indicate the proximity of aftershocks to these locations, but instead may indicate either that the frequency of shaking in these locations was optimal for people to sense (e.g. 2-4 Hz, Frankel 1994), or that anxiety about further destruction heightened their awareness to aftershocks. On 4 October 1833 a strong aftershock was felt simultaneously at Kathmandu, Allahabad, Berhampore, Malda, Purneah and Bhagalpore, and another on 18 October at Goruckpore, Kathmandu and Allahabad. A surprising number of aftershocks were felt in the slump belt region in 1934 and the largest instrumentally located aftershock in 1934 is also found in this region (Dunn et al. 1939).

Seeber and Armbruster (1981), and Chander (1989) propose that the 1934 earthquake ruptured a region forward of the main frontal thrusts of the Himalaya, at least as far south as the slump belt. High intensity shaking was also observed near the Greater Himalaya and central Nepal near the instrumentally determined epicenter approximately 100 km north of the slump belt (Pandey and Molnar, 1990). If it is assumed that the 1934 earthquake was $M_0=8.1$ its rupture area could easily extend embrace these two regions and extend an equivalent distance, or greater, along strike. However, the 1833 earthquake with a moment magnitude of 7.6-7.8 is unlikely to have ruptured an area more than 70 km on a side. The absence of catastrophic damage at the forts of Chisapani and Mukwanpur argues against a rupture zone centered at or near latitude 27°N , and it seems unlikely that rupture further south (beneath the plains) could generate $>30\%$ destruction in towns in southern Tibet. Thus the rupture zone of the 1833 earthquake appears to have been centered in northern Nepal or southern Tibet, and unless it was a thrust of unusual aspect ratio it would not extend beneath northern India. Thus the inferred intensity VIII and IX shaking in the Gangetic plain may have resulted from basin resonance, and not from the underthrusting invoked to have occurred during the 1934 event.

Following this line of reasoning, if a $M=7.7$ 1833 earthquake near the Greater Himalaya could generate intense localized shaking in the Gangetic Plain, so too could the Bihar 1934 earthquake. Could the slump belt in 1934 be a product of basin resonance and prolonged shaking thus not requiring slip to extend beneath the Gangetic Plain? Catastrophic lateral spreading occurred in the Alaska 1964 earthquake and was the result of vigorous and prolonged shaking of saturated sediments. It is not difficult to imagine that catastrophic lateral spreading could be confined to a region of especially intense shaking in 1934. The removal of the requirement for slip terminating near the slump-belt would remove the obvious difficulty that there is no evidence for a topographic bulge above the required southern edge of the inferred rupture. This was not revealed by leveling, nor is there any topographic evidence to suggest that the ruptures of previous shallow thrust earthquakes have terminated near the slump belt.

If it is assumed that the 1833 and 1934 earthquakes were both shallow thrusts, a limited number of geometries are possible if we additionally require that the two ruptures do not overlap. However, this requirement is not essential because the rate of development of available slip from Indian/Tibetan plate convergence is 1.5-2 m per century (Molnar, 1990), and slip released in the 1833 event could have been effectively renewed by 1934. The simplest relation for the two events is that a region north of Kathmandu ruptured in 1833 and that a region roughly four times the area ruptured in 1934 immediately to the east. However, alternative and not necessarily more complex rupture geometries can be envisaged that would also be consistent with the available data.

Isoseismal areas and Great Himalayan Earthquakes

Were the worldwide coefficients determined by Johnston (1994) for equation (1) appropriate to relate the felt areas of Indian earthquakes to their moment magnitudes, each event in Figure 5 would be represented by an horizontal line. However, intensity magnitudes determined for the four largest events show significant variance, indicating that the data for these events are unreliable, or that the Eurasian/Indian plate boundary requires adjusted coefficients in equation (1). Unfortunately the intensity data for the four great earthquakes are both confusing and incomplete. They are confused partly because intensity scales developed for the industrial nations are not easily applied to the type of construction and destruction in each area, and partly because those responsible for the compilation of intensity data were unable to visit much of the afflicted

areas to examine inconsistencies in written reports and hence apply uniform criteria to the observed damage. They are incomplete because isoseismal coverage is typically only for one half of the shaken region. The data in Figure 5 have area uncertainties of up to 50%.

For all four great earthquakes the maximum “felt area” isoseismal reported in the standard works on these earthquakes (Oldham, 1899; Middlemiss, 1905; Dunn et al. 1935; Tandon, 1953) yield moment magnitudes 1-2 magnitude units lower than the magnitude derived from the intensity IV isoseismal. Given that the intensity IV to VI isoseismals yield moment magnitudes consistent with those derived from radiated seismic energy, a possible conclusion is that the “felt area” isoseismal has been significantly underestimated for these events. Surface wave dispersion results in progressively lower frequencies dominating the accelerations at increasing distances from the epicenter and distant accelerations are presumably shifted to frequencies that are not optimum for human perception. Distant “felt” reports thus become increasingly “instrument”-based: long period oscillations in reservoirs, movements of chandeliers in churches, and slow movements of doors.

The 1897 isoseismals documented by Oldham 1899 consist of precisely delineated regions of damage to masonry structures, and approximate areas assigned grouped Rossi-Forrel Intensities. The low intensity isoseismal areas are completed by extending Oldham’s elliptic isoseismals to the north, however, the resulting areas may be uncertain by 50%. Isoseismal areas listed by Tandon (1953), Poddar (1953) and Ray (1953) for the Assam 1950 earthquake yield systematically low moment magnitudes unless these are doubled to include the areas not visited to the north and east of the epicenter. This extrapolation is undertaken “with the risk of great departure from the truth” (Ray,1953), a truth already uncertain for the same reasons that the 1897 isoseismals are unreliable. Estimates of lower and upper bounds for these isoseismals results in more than a ± 0.5 variation in assessed moment magnitude. Both Assam earthquakes yield mean moment magnitudes between 8 and 9.

The 1934 Mercalli intensity data reported by Dunn et al. (1939) yield reasonably consistent moment magnitude estimates although the values are somewhat higher than those derived by Johnston (1994). This is presumably because of uncertainties in closing intensity IV-VI isoseismals in southern Tibet. The intensity VIII area adjusted in Figure 4 to merge felt data from north and central Nepal (Pandey and Molnar, 1990) with data from Dunn et al. (1939) yield a good approximation to the observed moment magnitude.

The Kangra isoseismal data as reported by Middlemiss (1910) are unique among the four great Himalayan events in that they cannot easily be reconciled with the Johnston F94 coefficients. In particular, the mapped intensity VIII data are confined to two small regions, yielding an absurdly low estimate for moment magnitude ($M = 7$) compared with hitherto accepted magnitudes for the event ($M=8.4$). This anomalously small area is evident in Figure 1. Yet the estimated intensity V isoseismal area for this event is consistent with a $M = 8$ earthquake. Even were the two mapped intensity VIII areas to connect, which Middlemiss (1910) is adamant they do not, or the Kangra intensity VIII isoseismal to bend southward, as suggested by Molnar (1987), the increased area would bring the moment magnitude to no more than $M=7.5$. A localised intensity VIII area associated with a large earthquake would normally be interpreted as symptomatic of a shallow earthquake, or an earthquake in a region with abnormally high attenuation. Yet there no surface rupture was reported, and the widespread felt area indicates that the magnitude of the earthquake is typical of other great Himalayan events. The inversion of leveling data from the easternmost area is consistent with a slip on a shallow thrust of 7.5 m (Galalaut et al., 1994), again consistent with the occurrence of a great earthquake. A possible explanation for a small high intensity region and a large felt area is that the Kangra 1905 event was a slow earthquake. Slip on a shallow dipping buried thrust may have occurred at rates lower than the 1897, 1934 and 1950 earthquakes, insufficient to generate a widespread region of high accelerations but sufficient to stimulate long period waves resulting in a large felt area. In this interpretation, the high intensities observed near Kangra and Dehra Dun may have been associated with secondary shallow faulting in response to underlying slip.

Conclusions

A 1 million km^2 of northern India was shaken by a significant earthquake in 1833 that appears to have been centered in north-central Nepal. Although intensity X shaking occurred locally and more than 4000 buildings are reported destroyed, the loss of life (500) was small largely due to the occurrence of two large foreshocks hours and minutes respectively prior to the mainshock. A possible location for the epicenter of the 1833 mainshock is approximately 50 km north, or north east of Kathmandu, although the limited

number of observations in east central Nepal and southern Tibet permit an epicenter to the east of Kathmandu, close the epicenter of the 1934 Bihar earthquake. The 1833 earthquake resulted in damage intermediate in severity to the Udaypur $M=6.6$ 1988 and Bihar $M=8.1$ 1934 earthquakes. A mean moment magnitude of $M_0=7.7\pm 0.2$ is obtained by applying Johnston's F94 1994 relation between isoseismal areas and moment magnitudes.

The inferred $M < 8$ magnitude and consequent relatively small rupture area of the 1833 earthquake indicates that it contributed insignificantly to reducing potential slip in the Central Himalayan Seismic Gap between the Kangra 1905 and Bihar 1934 rupture zones. The slip associated with the event may have been 1-2 m, an amount consistent with a renewal time of 100 years. This and its proximity to the inferred rupture zone of the Bihar 1934 earthquake suggests that if the 1833 event occurred on a thrust fault it may have ruptured a region abutting or overlapping the 1934 rupture. However, although remarkable similarities between the 1934 and 1833 isoseismal areas exist, the mechanism of the 1833 event is unknown.

The application of the F94 Johnston (1994) algorithm to intermediate intensity isoseismal areas of four great earthquakes in the Himalaya yield moment magnitudes consistent with currently accepted values. Maps for isoseismal intensities less than V and greater than VII are either less reliable or incomplete for each of these earthquakes. Even when generous allowance is made for the northward extension of the perceptible felt area the intensity II area for the four events yield values that are too low by more than 1 magnitude unit, indicating that recalibration of the F94 algorithm for Indian earthquakes is desirable.

The Kangra 1905 earthquake is unique in that its intensity VIII felt area is anomalously small for a great earthquake. The seismically determined magnitude, the geodetically estimated slip, and the intensity IV-VI felt areas are consistent with an $8.5 > M_0 > 8$ event whereas the Intensity VIII area is appropriate for an $M_0 = 7$ event. A possible explanation for this anomalously small area of intensity $> VIII$ shaking is that the earthquake occurred with a substantial slow component, and that the observed high intensities were associated with secondary ruptures near Kangra and Dehra Dun. The absence of broad-band seismic data for this and other Himalayan earthquakes makes such a conclusion tentative. However, if slow earthquakes do occur in the Himalaya they would have the benefit of absorbing plate convergence with less high intensity shaking than normal high frequency earthquakes. Moreover, if other $M = 7$ earthquakes in the historic record represent the secondary seismic manifestations of slow great earthquakes the maturity of the Central Seismic Gap may not as advanced as currently believed.

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Table 1 Summary of Damage in Nepal and Tibet from J. Asiatic. Soc. Bengal, 1833.
414 Fatalities, 172 injuries and 4040 destroyed buildings are estimated in the Kathmandu Valley with additional fatalities and damage in villages to N and E.

named location	modern equivalent	MM intensity	E.decimal longitude	N.decimal latitude	houses destroyed	notes
Baghmati.	Bungamati	985.30	27.62	80	30% destroyed	
Bali	?	9		3		
Baneppa	Banepá	985.53	27.62	20		
Bara goan	Baregau	985.36	27.6	35		
Bareh	Bore	985.38	27.68	20		
Bhat Goan	Baktipur	10	85.43	27.65	2000	75% buildings, (max 4700 destroyed and >6 temples)
British Residency	Kathmandu	885.33	27.72	1		
Burba Nil Kanth	Burhanikanth	885.36	27.77	2		
Changu Narayan	Cangunarayan	885.87	27.69	2		
Changu.	Icangu	985.27	27.72	20		Old temple destroyed.
Chapaly	Capali	985.36	27.76	7		
Chappa goan	Capagau	985.32	27.6	35		
Chisapani	Chisapani	885.17	27.53	0		Damage to walls of fort
Chitlong	Chitlong	985.18	27.67	14		
Deo Patan.	Deupatan	885.32	27.75	30		Paspatnath temple undamaged
Dharmpur	Dharmapur	985.34	27.74	20		
Dharmtuli	Dharamtali	885.3	27.76	2		
Dhulaka	Dolacka	886.1	27.7			
Digarchi	Xigatse	388.9	29.29	0		not felt
Doti	Doti	580.9	29.3	0		
Dukele	Dhulikhel	985.58	27.62	21		
Duny Byass hills	?Jumbesi	9		40		
Gorkka	Gorkha	884.60	28	2		
Gou Karan	Gokarna	985.73	27.73	8		
Hal Chok	Dahacok?	985.27	27.72	3		
Handi goan	Harrigau	9		20		
Harra Sidhi	Harisiddhi	985.35	27.62	20		
Hukin gaon	?	9		1		
Kan Sing Choke	?Choksum	986	28.07			5 days of foreshocks
Kassa	Dram,Khasa	985.95	28			
Kathmandu.	Kathmandu.	985.33	27.72	400		Extensive damage
Kirtipur	Kirtipur	885.24	27.67	14		532 old and frail houses on ridge.
Kirung	Kyirong	985.29	28.48	60		15% destroyed
Kuknah	Khokna	985.30	27.63	130		
Kuti (Tibet)	? N. of Kodari	9-10	85.98	28.15	550	83% destroyed
Listi gaon	Listikot	885.94	27.89	0		
Lubu	Lubhu	985.38	27.62	25		
Mukwanpur	Mukwanpur	885.15	27.46	0		Fort damaged less than Chisapani
Mundun Pahar	? E to Tibet	>8				

Nag Desa	Nakdes	985.38	27.68	20	
Nala goan	Nala	9		11	
Narod Devi	?Nardevi	8		1	
Nayakoth	Nuwakot	885.23	27.8	3	
Pagah	Panga	985.27	27.65	24	
Pahon	Bahongau	8		3	
Palpa	Palpa	683.60	27.7	0	
Panouti	Panauti	985.53	27.57	19	
Patan	Patan	10	85.32	27.65	285
Peang	Pyanggau	985.33	27.58	8	
Phulam Chock	?Palchok	985.53	27.52	300	Temple destroyed
Phurphing	Pharphing	985.27	27.61	8	
Sana	?Sanagau	985.37	27.63	7	
Sana goan	Sanagau	985.37	27.63	40	
Sangu	Sanga	985.48	27.63	8	
Sankhu	Sakhu	985.47	27.72	45	Mahadei Temple nearly ruined.
Sassanelly	?Sisneri	885.40	27.62	2	
Sassanelly Hills	?Sisneri	885.40	27.58	20	
Selli goan	?	9		16	
Shipa	Sipatar	985.65	27.75	3	Small houses destroyed
Swambunath.	Swayanbhunath	985.28	27.71	3	Temple destroyed
Taibu	Thaiba	985.35	27.61	18	
Temi	Thimi	10	85.38	27.67	150
Teshu goan	?	9		25	
Tewanpur	?Makwanpur	9		10	
Thankote	Thankot	985.21	27.68	23	
Tingri	Old Tingri	486.5	28.5	0	
Toka gaon	Tocka	985.33	27.76	15	

TOTAL number of buildings reported destroyed 4652
(includes damage in southern Tibet)

Table 2 Summary of 1833 Intensity data from Indian Newspapers, (see Appendix)
compared to 1934 Bihar earthquake Intensity data from Dunn et al. 1939

Location	Mercalli Intensity 1833	Mercalli Intensity 1934	long dec.E°	lat dec.N°	1833 shaking duration,s	1833 shaking azimuth
Mainshock						
Agra	V	VI	78.02	27.13	5	
Allahabad	VI	VII	81.92	25.43	120	
Arrah	VIII	VII	84.67	25.57	60	N
Bankipur	VIII	IX	85.1	25.6		
Bankura	VI	VI	87.07	23.23		
Benares (Varanasi)	VII	VII	83.02	25.3	150	NW
Bhagalpore	VII	VIII	87	25.25	480	
Buxar	VII	VII	83.98	25.57	180	N
Calcutta	V	VI	88.4	22.57	120	N
Chandernagore	VI	V	88.4	22.73	180	
Chapra	VIII	IX	84.73	25.78		N
Comercolly (Kumarkhali)	V	VI	89.18	23.87		
Dinapore	VIII	VIII	85.05	25.63		
Delhi	IV-V	V	77.2	28.7	300	NE
Futtigurh	IV	VI	79.6	27.3		
Gazeepore (Ghazipur)	VI	VII	83.5	25.6		
Goruckpore	VIII		83.4	26.8	180	E
Hathras	V	VI	78.05	27.6	60	NW
Hazaribagh (Hazareebad)	IV	VI	84.27	23.95		

Jabalpur	II-IV	V	75.98	23.33		(Campbell, Nov. 1833)
Kathmandu	VIII-X	IX-X	85.33	27.68	60	NE
Kirong (Kyirong)	VIII		84.25	28.45		(Campbell, Dec. 1833)
Lhasa	I		91.17	29.68		(Campbell, Dec. 1833)
Lucknow	VII	VI	80.93	26.87	180	
Lohoghat (Lohughar)*	II		80.08	29.38		(Baird-Smith, 1843)
Meerut	V	V	77.72	29.02	15	
Monghyr	IX	X	86.56	25.38	60	NE
Mullye (Murliganj?)	V		80.72	26.92	350	N
Murshidabad	V	VI	88.4	24.2		
North Tirhoot	VIII	IX	85.4	26.4		
Nusserabad (Nasirabad)	I	IV	90	24.43		
Patna	VIII	IX	85.1	25.6		
Rhotas Hills	IV	VI	83.83	24.63	120	
Purnea	IX	IX	87.47	25.77		NE
Rungpore (Rangpur)	VI	VI	89.3	25.75	40	
Tingri, Tibet	IV	V	86.5	28.5		
Tirhoot (N. Tirhoot)	IX	IX	85.4	26.23	60	E
Tirhoot (Muzaffarpur)	IX	IX	85.4	26.12	60	N
Xigatse, Tibet	I	V	88.7	29.3		(Campbell, Dec. 1833)
Aftershocks						
Berhampore 4 Oct	V		86.1	300	0	
Jaunpur 9 Oct	V		82.68	25.75	3	
Malda 4 Oct	V		88.13	25.03		
Goruckpore 18 Oct	VII		83.4	26.8	60	E
Bhagalpore 4 Oct	VII		87	25.25	10	
Purneah 4 Oct	V		87.47	25.77		

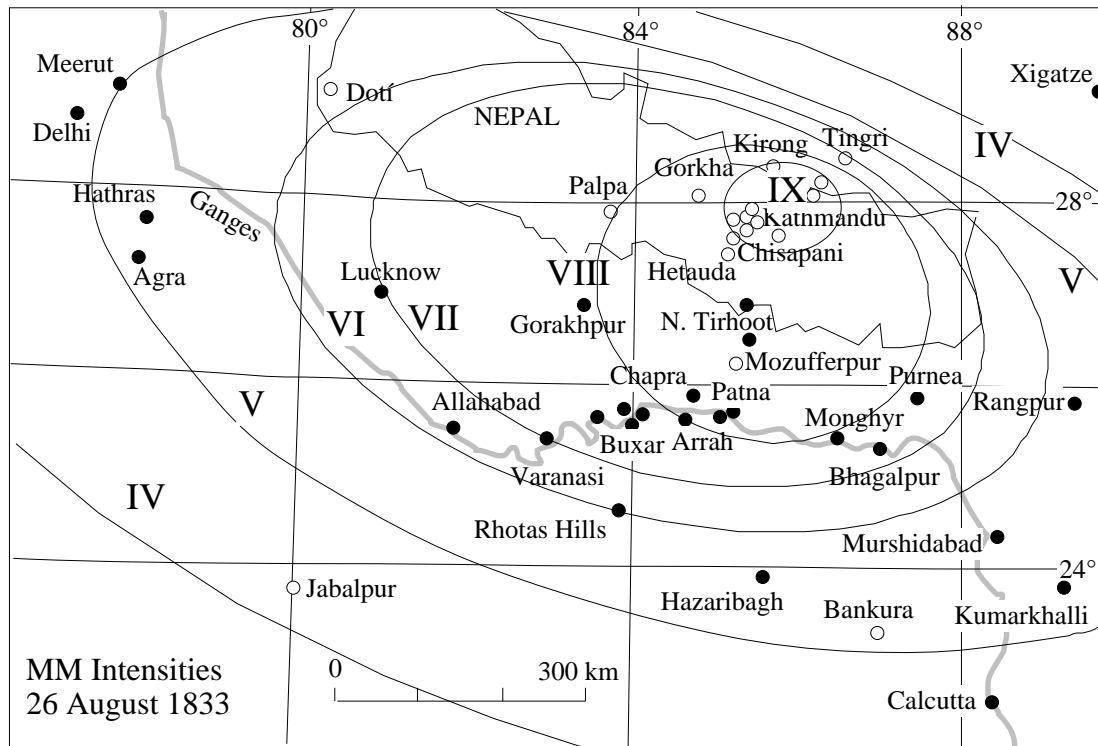
* Baird Smith 1843 citing McClelland, p.1051 (note that due to misnumbering a second page 1051 occurs, and pages 1053 to 1056 appear thrice distinguished by * and † symbols).

APPENDIX

Accounts of 26 August 1833 Nepal earthquakes and aftershocks.

Times in the original articles are converted to a 24-hour-clock. Note that these original times are generally unreliable because they are expressed in local time usually set by a local sun clock and span a 1 hour time zone. A precise astronomical clock was stopped in Calcutta by the second foreshock at 23:34' 48". The mainshock occurred at approximately 23:54 and the first foreshock at 17:00. Mercalli Intensities are assigned to the mainshock and to the five reports of aftershocks.

Three reports from Nepal containing the observations of A. Campbell are included in addition to an anonymous commentary from Agra.



Appendix figure. Locations of towns reporting the 1833 earthquake. Solid circles from newspaper reports and journal articles. Open circles from Campbell, 1833.

AGRA

V

The Earthquake - Several shocks of an earthquake were felt in cantonments, as also in the city of Agra, on the night between the 26th and 27th instant. The shocks came in rapid succession, were strong, and lasted a few seconds each, but we have not heard that any accidents have happened. -

(The India Gazette, Calcutta, Tue. Sept. 12 1833 III, 872., reprinted from the *Mofussal Ukhbar*, Aug. 31. 1833)

AGRA. The Earthquake.

The following account from correspondent in Agra summarises accounts in the above newspaper reports south of latitude 26°N, and adds a few locations not encountered in the primary articles that follow. It is included because it appears to be a systematic list of 1833 settlements from which news of the event was expected. It claims to be the first of two reports but a search for the second which purports to describe damage north of 26°N has been unsuccessful. Mullye is not mentioned in this report suggesting that it is located north of latitude 26°N.

We are happy to perceive a hint in the Calcutta Courier, that the Secretary to the Asiatic Society is likely to favor the public with an account of the Earthquake of the 26th of August. To assist in rendering this as complete as possible, we have been induced at this early period to take a review of the information already collected for the purpose of showing what is yet wanted from individuals residing at places where the shock was sensibly felt. We would strongly recommend that a set of questions be circulated through the government by the Asiatic Society, as it is probable that there are many subjects connected with the sciences, besides the phenomena attending the earthquake, on which a light may be thrown by means of such an enquiry. We intend in the first place to confine our remarks to the sensible effects of the earthquake in different situations, and here we shall be obliged to recapitulate facts with which most of reader are already familiar. The earthquake must have proceeded from a point or from an extended line or a space. The first subject therefore, seems to be , to determine these limits , and in order to do this we ought properly to possess an understood measure of intensity, so that we might ascertain the our vicinity to the vortex or centre. Supposing that we assumed the earth to be of equal solidity throughout its surface, and the Earthquake had proceeded from a certain point, we should find a regular succession of accounts , which would be exactly similar at similar distances. If the point therefore is ascertained, and any discrepancy appears in the accounts , we are obliged to refer this to the quality of the intervening strata. We may premise that there were 3 severe shocks; the one at sunset, the other at a little past 11, more severe, and the 3rd at or near midnight , the severest of all. Now did these three happen at the same place or at several places? If they happened at the same place , we should, by commencing with the accounts, from the eastward remote from the epicenter, find exactly similar accounts, to that which we would have from the westward, and the difference of strata would have no avail, for having obtained three different degrees of intensity, they would all shade into obscurity (if we may be allowed to use the expression) in the same order at proportional distances.

22°N

We shall proceed from the southernmost point from which information has been obtained and take parallels of Longitude from east to west. From the westward [this should be eastward?] of Calcutta no recounts have been received. At **Calcutta and Dum Dum** 2 shocks were felt, the first comparatively light at 23:36, which stopped the astronomical and other clocks. The second came on at 23:56, occasioning the doors to rattle while the punkahs, the wall shades, &c were all thrown into violent agitation. It lasted, about 1 minute. This is all that has been recorded for this parallel, no accounts having been received from **Midnapore, Singboom, Oodeypore, &c.**

24°N

In 24 latitude there are no accounts from **Dacca** - At **Comercolly** two shocks were felt, the first at 23:45 lasting nearly a minute, the second *somewhat slighter*, about 10 minutes after. At **Moorshedabad (=Berhampore)**, the 1st shock was felt at 19:00 but two others about midnight within ten minutes of each other shook the house, awakened the birds, and caused the hanging lams to vibrate for 4 minutes afterwards. So severe was the shock that the writer feared his house would fall. The earth trembled so violently that it was with difficulty one could keep his footing.

At this interesting point, our information terminates, and we pass on to Hazareebad (**Hazaribagh**) on the southern side of the concussion. At this station the early shock at 19:00 was not felt; but one at 23:30 and a second half an hour afterwards, lasted 2 minutes causing the puncka to swing and the door to rattle loudly. In a letter from the **Rotas Hills**, the first shock was felt at 23:10, a second rocking came soon afterwards, and 23:11 it returned more severely lasting not less than 2 or 3 minutes; the roof of the house creaked, and the doors and windows rattled.

There are some discrepancies in this parallel which might perhaps have been explained had we possessed more extended accounts. For instance, the slightness of the last shock at Commercolly; secondly the sudden increase at Moorshedabad. the slightness of the effects at Hazareebag, and the severity, considering the remoteness under the Rotas Hills; we should presume the situation of the last account must have been made considerably to the northward of Hazareebag.

25°N

We shall now take the parallel 25 from whence the fullest statement shave been obtained. From **Sylkat** we have no accounts, our first are from **Rangpore** nearly in 25, where the shock was felt as at Moorshedabad. The first took place at a little after sunset, slight and of short duration. The second at 23:30 being strong lasting about 30 seconds and the 3rd still more severe of 40 seconds duration.

No accounts have been received from **Dinapapore, Malda or Raymahil** (Rajmahal), and we are obliged to pass on to **Poornea**, where the shock produced still more severe effects. the 1st shock was felt at 17:00 slightly, the 2d. at 23:00 severe and the 3d. at 23:18 most violent. the birds were driven from their nests; men were scarce able to stand; cattle ran wild with fright; several old buildings in the town tottered to pieces; a part of one in the

station partially sank; a heavy cornice fell, every building suffered more or less, and a recently vacated upper roomed house, had not an arch left. Large masses of bricks have actually fallen out of the walls. The roofs in many places split, and the beams and Burgahs separated an inch and more. The out-offices in the compound are a heap of ruins. The shocks are mentioned as occurring from 23:30 to 08:00. The last was somewhat severe; no mention is made of a subterranean sound.

Our next accounts are from **Bhagalpore**. the first shock was felt at 23:15 where a tremulous motion was felt for 3 or 4 minutes; at about a 23:45 the 3rd shock was felt when the chairs when the chair moved and the door rocked about; this lasted about 8 minutes. Between this and daylight 3 other shocks were felt, but none equal to the first; a rumbling noise was also heard, but not very loud.

From this we proceed to **Monghyr**. At this station the first shock occurred at 5 minutes after sunset accompanied by a rushing noise shaking like the movement of a steam engine. the 2nd took place at 23:25 and the 3rd at midnight, the 4th at 02:00. the 5th at 03:45 &c. The 2nd and 3rd were most severe causing considerable damage to the houses of which 34 have been more or less injured by the falling of the balconies and balustrades, and by the cracking and separation of the walls and beams. The ground seemed to rise in waves about a foot in height. The lamps were all extinguished, making with the glasses on the sideboard, agitation of the jilmils and rumbling under ground, which accompanied the earthquake a frightful noise. The first shock seemed to last for 30 seconds, the 2nd and 3rd about a minute each. Mr. H. and Colonel B., Mr. pages and Captain Watson's houses have sustained considerable damage. large portions of the Rampart of the fort have fallen down. The shock was distinctly felt by the people in boats. Another slight shock occurred at 21:00 of the 27th. The Commissioners house is situated at the highest point of the station, and has suffered least, though the earthquake was severely felt there.

From Monghyr we proceed to **Patna** having received no accounts from **Bar**. The first shock was felt there at about 18:00, rather slight. The next was felt when a number of houses fell and various sorts of injuries were sustained. Rajah Khan Bahadoor's stable fell by which 7 of his horses were killed. Capt Elliot's house was also leveled with the ground. Mr. E. DeCosta's house cracked. At 23:30 says one, I was awakened by a horrid rattling and shocks, apparently from the E. to W. with a rumbling noise, the servants running into room in great consternation. the last shock occurred at midnight which was the most severe. At **Bankepor**, (=Bankipore) 6 miles from Patna, houses were cracked, amongst which were the magistrates Kutchery and in the city, the opium godown has shared the same fate as also [the] gateway built by Maha Rajah Mohur Jay Singh, while many Pucka dwellings have entirely fallen. 18 shocks were afterwards felt, but they appeared continuous; the last was at 08:00. At **Dinapore**, (Danapur) 10 miles away from Patna the former Brigade Major's house was split.

At **Arrah**, a little east of Dinapore, the first shock was not felt at 23:15, one occurred lasting a couple of seconds, the second began in about 10 minutes afterwards and was the most severe of the two. It commenced by a slight tremulous motion which gradually increased to the most terrific undulations, and was accompanied by a loud rumbling noise like thunder underground. Door, windows and every other article of furniture were thrown into a most violent agitation, several walls fell and some roofs were thrown off.

At **Chuprah**, in nearly the same longitude but a little to the north, the first shock at 17:00 was felt but slightly; at 23:00 another came on accompanied by a tremendous rumbling, and a violent rocking of the house. At 23:15 the severest shock commenced with a tremulous motion, and a noise like thunder, followed immediately by a very long and awful agitation of the earth, which vibrated in a horizontal direction north and south. Slight shocks continued until 08:00 and a tremulous motion at intervals during the day. large pieces of plaster fell from the walls in the rooms; native dwellings have been destroyed; 2 miles from thence the earth opened; in consequence of the injury to the court house has sustained the Cutchery is now held in a tent.

At **Buxar**, the force lessens - several smart shocks were felt, the first decided one took place at 23:20 but the smartest at 23:55. The motion was so strong as to upset several wall shades and glasses in one of the Bungalows there and the general rattling of the doors and windows and the creaking of rafters were really most alarming. The indigo factory was cracked, a rocking motion was felt by an officer in a budgerow, 5 miles above Buxar at Koorantadhee immediately opposite Buxar, it was so slight as to scarce waken a single individual.

At **Gazeepore**, the first shock felt was at 23:00 and the second at an interval of 40 minutes. The first was slight, the second as it were 4 or 5 successive undulations accompanied by a subterranean noise, heard however by very few. The cots of the soldiers were violently agitated so as to cause the occupants to start from their sleep, the walls and joints cracking.

At **Benares**, the first shock at 18:00 was not felt, at 23:00 a shock took place which continued for 4-5 seconds. This was succeeded by another not very violent for 4 or 5 seconds; a more severe one was afterwards felt which lasted 2.5 or 3 minutes and the earth ceased to shake gradually.

At **Alahabad**, only two shocks were felt; at 23:30 the same phenomenon presented itself with a more striking character, the short but quick vibration continued for nearly 2 minutes, accompanied with noise from the doors, windows &c. and a dreadful hollow sound from the river.

We wish we could have completed this with a report from **Culinger**.

Having now finished an account of our principal parallel, we shall proceed to draw the inferences from the limited facts which have been collected. Rungpur and Moorshedabad appear equidistant from the centre. The former is equally far from Purneah as Moorshedabad is from Monghyr while at the latter two stations, the shock appears to have produced equally severe effects. At Bauglepore, although very near to Monghyr the effects are wonderfully lessened, leading one to the idea that the ground under Bauglepore was in no ways connected with the earthquake, that it was more solid, &c and therefore that the tremour lasted longer. A sound was heard at Bauglepore, Monghyr and less so at Purnea. The rumbling of stones, the rush, as it were of water, and of a mighty wind, are accompaniments of earthquakes which will probably lead eventually to the discovery of their cause. The appearance around Monghyr as well as the hot springs there testify to the volcanic nature of the subjacent strata.

At Patna the effect seems still nearly as severe, apparently diminishing towards Arrah. Our previous accounts from Hazareebag, indicate that the effects decrease to the southward, while those from Purneah on the one side and Chuprah on the other indicate the boundaries E. and W. showing also the severity in the latter case, that the effects of the earthquake are to be in a northern direction from these stations. We observe the gradual diminution of the effects Arrah until we come to Allahabad and may almost conclude that the last shock was just perceptible at Calinger.

By comparing Moorshedabad and Rungpore, we find them equal, and by comparing in the same manner Allahabad and Calcutta we shall also find that the effects are similarly described and that they are at equal distance respectively from Patna and Monghyr. The facts, then tend to the conclusion that a given concussion produces similar effects throughout the earth's surface at equal distances. Should such be the case, and our information here be accurate, we should with these data be able to solve the following quotation:- *Given the effects of an earthquake at 2 known points, and also the direction required* (missing words in the printed version of this statement) *the point from whence the concussion arose..* With this idea we have measured the distance between Calinger and Patna, and we have assumed that at Agra the effects were similarly felt as at Calcutta, we have put one leg of the compasses on the map at Agra, and swept a circle which passes through Gazeepore, Guruckpore up the course of the Gandack to its origin in the snowy mountains.

Now we have already had an account of so that the effects of the Earthquake must according to our data have been more northerly. It was however felt at Delhi, in a similar manner, and if we take the same radius we shall still keep to the source on the Gandack, from which we have not as yet obtained any accounts. We shall reserve another parallel for our next number.

(reprinted from *Mofussul Akbar* Sep. 21 1833. In *The Bombay Courier*, 476, Oct. 8 1833)

ALLAHABAD 26 August

VI

At Allahabad we regret to hear, that death has lately been truly alarming and frequent in its occurrence [cholera epidemic]. We are also informed that two smart shocks of an earthquake were felt there during the night of the 26th. Our informant who resides at the fort, states that he was awoke from a sound sleep at 23:00 in consequence of the tremulous motion being communicated to him by the bedstead - at 23:30 the phenomenon again presented itself with a more striking character; the short but quick vibrations sensibly continued for nearly two minutes accompanied with a noise from doors, windows &c. and a dreadfully hollow sound from the river.

(reprinted from the *Calcutta Courier* in the *Bengal Hurkaru and Chronicle* XII(58), New series Thu. Sept 5 1833)

ALLAHABAD 16 Sept.

VI

August 26 First shock 5 minutes before sunset, not severe; close, hot; light airs from NE; barometer 29.273. At 04:26 bar. 29.213. On the 25th same hour 29.253; thermometer 88 on both days. About 11 PM and 11:30 very severe shocks were felt; loud noise, resembling distant thunder was heard. The river Jumna was thrown with violence against the banks. Many persons left their houses, both Europeans and natives.

(The *India Gazette*, Calcutta, Sept. 24 1833, II, 882)

ARRAH 27 Aug.

VIII

Last night the inhabitants of this town were thrown into a state of alarm by two severe shocks of earthquakes. The first took place at 11:15 and lasted for about 10s. The second began in about ten minutes and was the most severe of the two. It commenced by a slight tremulous motion which gradually increased to the most tremendous undulations, and was accompanied by a loud rumbling noise, like thunder, underground. It appeared to proceed from N to S. Doors, windows and every article of furniture were thrown into the most violent agitation: several walls fell and some roofs were thrown off. All rushed to the streets and the whole town was in a state of commotion. We understand that some of the *sahib leg* abandoning their beds ran into the streets in great consternation.

(Bengal Hurkaru and Chronicle XII(58), New series, Thu. Sept 5 1833 reprinted from The India Gazette, Calcutta, Wednesday Sept. 4, III, 865)

BENARES 27 AUGUST (now Varanasi)

VII

An earthquake happened here on the 26th instant, the particulars of which are as under. About 23:00 26Aug, a shock was felt which continued 5-6 seconds. This was followed by another, though not very violent, of 7 or 8 seconds duration. On going out to the verandah I found several of my friends and the domestics in a state of alarm. After a lapse of 5 or 6 minutes I returned to my chamber, but no sooner had I entered it, than a more severe violent shock was felt. This lasted 2.5 or 3 minutes and the earth ceased to shake gradually and imperceptibly.

(The India Gazette, Calcutta, Wednesday Sept. 4, 1833, III, 865., reprinted in Bengal Hurkaru and Chronicle XII(58), New series, Thu. Sept 5 1833)

BENARES

VII

A native letter from Benares mentions that three shocks of an earthquake was felt at that station. It however appears to have most severely experienced at Boglepore as detailed in a letter in the John Bull. The first shock was felt at 11:30, the undulations from the NW passing to the east. An hour after a second shock was succeeded, more severe than the first, and afterwards six partial shocks ending at 2:30. The last was accompanied by a sound resembling the rushing of a stream of water. A constant tremor of the ground was felt from 12 o'clock until daybreak.

(The India Gazette, Calcutta, Sept. 26 1833 III, 884)

BERHAMPORE Oct 4 1833 Aftershock

This morning, at a well known village called the Cuttereah, about 10 miles below Berhampore, while we were out for a walk we distinctly felt the shock of an earthquake. It came about 07:45 and lasted fully 5 minutes; its direction was from north to south: the shock was slight but distinctly felt so that you see earthquakes are becoming more common now.

(In Bengal Harkuru Wed Oct 9 printed from Indian Register)

BHAUGULPORE 27 AUG. 1833

VII

About a quarter past 11 last night, I was roused from my bed by a violent shaking of it, so much so, that at first I thought someone was actually moving the bed about. I jumped out and saw the oil in the lamp moving about in tremulous motion which lasted about 3 or 4 minutes. I waited a little and got my wife and family on the verandah, when we plainly felt the chairs move and the doors rocking about. This lasted nearly eight minutes, and between this and daylight three other shocks were felt, but none equal to the first; a rumbling kind of noise was heard, but not very loud. In the year 1806 I felt an earthquake at Bencoolen as severe as this, but never before in this country.

(The India Gazette, 1833, Tuesday Sept. 3, III no. 864)

subsequent commentary on above:

Sir,- The account contained in your paper relative to the late earthquake at Bhaugulpore is indeed terrific. The shock of 8 minutes duration must have been confined alone to your correspondents premises. His house must be evidently built of something more substantial than pukka materials, else how is it possible that it stood. Your correspondent adds, that he felt the shock at Bencoolen in the year 1806 as severe.

Judging from this , he must be an old stager; and consequently when age and fear act as existing agents, some allowances are admissible. I remain your obedient servant. Anti Veteran.
(The India Gazette, Calcutta, Wed. Sept. 18 1833, III, 877)

BHAUGULPORE 4th Oct. 08:10. aftershock

10 s of shaking described at length from the shock of the 4th Sept. 08:10. Birds disturbed. "A mud hut about the neighbourhood had fallen, and an aged man, who could not get out in time, was buried under the ruins, and was taken out dead afterwards.

The India Gazette, Calcutta, Fri. Oct. 11 1833 III, 897

BULDEEAH - Inundation and Earthquake 31 Aug. 1833

A letter from a correspondent at Buldeeah dated the 31st. ultimo, states that the place had been visited by the most destructive inundation of the Kumlah river ever known. The river was increased by torrents from the Nipaul mountains so suddenly, that hapless beings were drowned asleep in their houses at night. Cattle were swept off, and immense trees of the forest came rolling down the rapid stream that had undermined or cut away the banks on which they have flourished for many years in perfect safety. The earthquake of the 26th and 27th was also felt very powerfully at the same place.

(The Bengal Harkuru and Chronicle XII(67)New Series , LXIV, 5768, Old Series 16 September 1833)

BUXAR Aug 27

VII

Last night several very smart shocks of an earthquake were felt. The first decided one took place at 23:20, but the smartest of all at 23:55, each continuing for several minutes in a direction from N. to S. The latter was so severe as to cause the members of all families resident here to run into the open air to secure themselves against the danger which seemed about to overwhelm them. the motion was so strong as to upset several wall shades and glasses in one of the bungalows here, and the general rattling of doors and windows , and the creaking of rafters were really most alarming.

The undulating motion of the ground was so great as to cause horses that were asleep to start up suddenly with the mark of alarm, and the birds roosted upon the trees to rise into the air, uttering wild cries.

Strange to say the violence of the shock seemed a good deal bounded by the river, as at KORUNTADHEE, immediately opposite to Buxar, the motion of the earth was so little felt as hardly to awaken a single individual, - whereas on this the right bank of the river, all were obliged on the instant to evacuate their habitation and run into the open air.

The effect on the water about 56 miles above Buxar, as described by me, an officer luogoo'ed in his boat, was that of a rocking motion, as if occasioned by a heavy swell consequent on an east wind.

I am glad to be enabled to add, that no serious injury, has occurred, unless one or two cracks in an Indigo factory bungalow, a few coss off, may be accounted as such I have since heard that the shocks were most severely felt at BHOJEPURE, 15 miles distant in an E direction.

(The India Gazette, Calcutta, Monday 9 Sept. 1833, III, 869)

note: a kos is 3000 paces or approximately 2.3 km (page 198 in Phillimore, R.H. , Historical records of the Survey of India, Vol. II, 1800-1815, pp 477) The above account, though taken at face value by the commentator in Mofussul Ukbar of Sept 21 1833, and repeated by Mallet, 1852, is ridiculed in a reply in the Bengal Harkuru, Fri. Sept 20 1833, an extract of which is reproduced as follows:

Dear Sir, We have all been a good deal amused here, with the account given in your paper of the 6th instant, of the Earthquake at Buxar. "It would certainly be important if true"- but theres the rub! Why! Mr. Editor, your ordinary discrimination must surely have been in abeyance when you admitted so bright an idea as that, "the effects of the shocks could even appear to be bounded by the river.

The fact is the motion of the earth was just as severely felt at Koruntdhee, as at Buxar on the right bank of the river, with this small difference, that your gallant and philosophical correspondent having previously confined a considerable time in his boat going down the river, sacrificed a little to freely to the Jolly God, at a certain glorification party on the night in question.....Servants, syces &c. rushed out with one accord in the greatest state of alarm. In short it was impossible not to have felt it. Yours truly VINDEX. Buxar Sept. 13 1833.

(Bengal Harkuru, Fri. Sept 20 1833,)

CALCUTTA

Sir,- The correspondents who have favoured you with accounts of the Earthquake that was lately felt in various parts of Hindoostan, state in vague terms the direction which the earthquake took in its progress. Do they mean to say that the direction was north and south or from north to south (for these expressions convey different ideas to the mind). If the latter, what means have they of ascertaining the fact? Your obedient servant, B.

(The India Gazette, Calcutta, Tue Sept. 12 1833 III, 872.)

CALCUTTA

V

Two shocks of an earthquake were felt on Monday night: the first occurred as is shown by its stopping an astronomical clock precisely at that time 23:35, and was comparatively slight and of short duration: the second was far the most violent we ever remember to have experienced - the doors rattled, as if shaken by a storm of wind, the bed in which we slept was heavily for more than a minute, from north to south with a gentler undulation afterwards in an easterly and westerly direction: the punkahs, the wall shades, the tables and chairs were violently agitated; and this second shock endured we should think altogether, for upwards of two minutes. It came on at about 23:56. The natives felt it in their huts and blew their horns as usual, and the crows and adjutants were disturbed by it and made a great noise, flying off from the houses and trees where they had taken roost.

Bengal Harkuru and Chronicle XII(51) New Series, Wed Aug 28 1833.

CALCUTTA Aug 27 1833

V

A slight shock of an earthquake was felt in Calcutta last night (Monday) at about 11:35. A stronger shock was felt exactly at 23:57.

subsequent commentary on above

Sir you must be a sound sleeper from your editorial of this morning about a slight shock of an earthquake felt last night. I have witnessed many; and, **except that experienced in Lord Lake's camp on the night preceding the storm of Ally Ghur, (note: 1 Sept. 1803 Kumaon earthquake).** I remember nothing of the kind comparable to the lengthened rocking of my couch last night in the upper rooms of the Bengal club. I really expected to see the pillars of the verandah, if not the building itself come down; and waited with tranquillity, for my "disruption of the visible world" not the oft recurring wish to behold what is beyond.

Cleophas. India Gazette, Calcutta, Wed. Aug. 28, 1833 III, 859

CHANDERNAGORE

VI

The following is an extract of a letter from Chandernagore:- " In the night of the 26th-27th two shocks of an earthquake were felt in Chandernagore; the second much more violent, continued about three minutes and commenced about half past 12 (vers minuit et demi). The attic of a house has been thrown down, but no other accident has occurred" We suspect our correspondent has mistaken the time of the last shock.

Bengal Harkuru Thu. Aug 29 1833 XII No 52 New Series.

CHUPRAH 29 August

VIII-IX

In the night of the 26th instant we were thrown into great consternation by the most awful shocks of an Earthquake, perhaps ever felt in this part of the world. The first was at about 5 o'clock in the evening and slightly felt. At midnight I was suddenly aroused from sleep by a tremendous rumbling noise and violent rocking of the house, which continued some time. I remained in the verandah thinking all was over, when in about a quarter of an hour another shock began, first with a tremulous motion and a noise like thunder, followed immediately by a very alarming and awful agitation of the earth, which vibrated dreadfully in a horizontal direction North and South.

We all rushed down-stairs away from the house and continued in an open building until daylight, and as I did not sleep again, I observed that slight shocks continued till 8 in the morning; indeed a slight agitation was felt at intervals throughout the day. Large pieces of the cornice and much of the plaster fell from the walls the rooms.

All the people ran from their houses and several native dwellings have been destroyed. I have since heard that three people were killed by the falling of their houses. As such severe shocks are unusual in this part, you will probably learn further accounts by the papers. Two miles from this the earth opened and a chasm

of considerable depth formed. In consequences of the injury the Court-house has sustained, Cutchery is now held in a tent.

(The India Gazette, Calcutta, Friday Sept. 6 1833, III, 867, reprinted in Bengal Hurkaru, XII(60), Sat Sept. 7 1833.)

COMERCOLLY (Khumarkhali, 23°52', 89°11') August 27 1833

VI

Two very smart shocks of an earthquake were felt here last night (The India Gazette, , Tuesday Sept. 3, 1833, III no. 864)

DELHI Aug. 27

V-VI

An earthquake was experienced at Delhi at a quarter before 1 AM on the 27th inst. which lasted 4 1/2 to 5 minutes; the shocks (by undulations) were rapid and distinct and their direction from SE to NW.

(Delhi Gazette, 31 August, first reprinted in the 11 Sept. issue of India Gazette 871. and again Wed. Sept. 18 1833, III, 877)

FUTTIGURH - 28 Sept. 1833

V

Your 'excellent earthquake' was felt here very sensibly, I was sound asleep when it occurred, but the clattering of the doors and windows soon awoke me and made me leap out of bed. From the harmonious cawing of the crows and the sweet carolling of the minahs (?), I soon returned to my nest. A neighbouring house was much shaken.

We had subsequently visited by a meteor so brilliant that I was again woken from a sound sleep.

India Gazette, Calcutta, Oct. 10, 1833

GORUCKPORE Aug. 27 1833

VIII

The first shock was felt about 7 p.m. yesterday and was slight. At about 23:20 there was a severe shock, which lasted nearly 2 min.; this shock awoke without exception, that I have heard, every European resident at the station, many of whom ran out of their houses, fearing that they would tumble about their ears, and really the shaking was so violent that it felt exactly as if the walls must be thrown down. After this shock passed away there was a continued vibration of the ground for about 20 minutes; at a few minutes before 12 another shock, much more violent and of longer continuance than the last mentioned, was felt, when open doors were slammed to, the jilmills rattled and the violence of the shaking was such that it seemed impossible for any fabric to stand it the city was in an uproar, all the natives ran out into the street and continued out the remainder of the night. There was an almost constant vibration felt until nearly six o'clock this morning and three shocks, much less severe than the two between 11 and 12, at intervals between 12 and 6 ; since all has been quiet. One or two houses in the town were shaken down but the only damage I have heard in the cantonments is the cracking in two places from top to bottom of the outer verandah wall of the civilians bungalows. It was a beautiful moonlit night without cloud or a breath of wind.

The shocks appeared to run from east to west-it was not an undulating motion such as I have former occasions felt, but the sensation to a person in bed was more like what be felt if the bed were seized by several hands and shaken violently backwards and forwards. The natives here have scarcely recovered from the fears yet; they say they never experienced anything of the sort before, and it seems surprising that no houses were injured more materially, considering the violence with which they seemed to be shaken,

The river is exceedingly high and all the jeels and low ground with which it can communicate more extensively filled and flooded than they have been since the great flood in 1823, though the local rains have not been excessive; indeed there has scarcely been an average fall and the weather has been delightful.

Bengal Hurkaru and Chronicle, XII(59), New Series, Mon. Sept. 6 1833

GORUCKPORE (18 October aftershock)

VIII

A correspondent writing from Goruckpore says that the station was visited 18 Oct. 04:40 by "a most tremendous earthquake" which came from East to West and lasted nearly 1 minute. He adds that it was much severer than that which was experienced on the 26 th last. It is singular that we felt nothing of the kind here, nor have heard anything of the earthquake from other quarters.

(The India Gazette, Calcutta, Sat Oct. 26 1833 III, 910, reprinted from the *Englishman*,)

HATRASS (now Hathras)

V

A considerable shock of an earthquake was felt at Hatrass. It appeared to last a minute and it seemed to be from NW to SE.

(The India Gazette, Calcutta, Tue Sept. 12 1833 III, 872, reprinted from the *Mofussal Ukhbar*, Aug. 31. 1833)

JIONPOR 10 Oct. 1833 Aftershock (*Jaunpur*)

V

I lose no time in telling you of another earthquake, which was felt here yesterday at or about 8 in the morning; the shock was sudden and smart and lasted a few seconds. It shook all the jillmills and doors.

Jionpor 11 Oct. 1833

(The India Gazette, Calcutta, Sat Oct. 26 1833 III, 910)

KATHMANDU, NEPAL Aug. 27

IX-X

Have you ever experienced the sensation from the shock of an earthquake? If not pray earnestly you may be spared a practical knowledge of this huge and incomprehensible phenomenon. Last evening about 18:00 we had in the residency grounds, and throughout the valley, a severe shock of an earthquake. I was in the house at the time. Doors, jillmills, chairs and tables commenced shaking most violently, then the house began to move, and when I got outside the rumbling noise of cannon driving over a drawbridge, was most distinctly audible, and gave the idea of vast bodies moving at full speed close underground. The trees and shrubs moved from their roots with each undulation of the ground, and I could distinctly see my house reeling in unison with the trees around it. I pitched a tent to have a place of refuge against a repetition of the business. However, bed time came and we all save H_ went to bed; -but at 10:45 another and more violent shock than the first obliged us to turn out, and as I rushed out of the house instantly, I had a noble view of the effects of this one. The ground moved in a long and even swell for about 30 or 40 seconds, and the doors and windows of our houses shook most vehemently. The whole people of the place set up a shout -the Hindoos called on Ranjee, and the faithful uttered long and deep prayers to God and his prophet:- all were in confusion and amazement- when at 11:02 we heard the rumbling of distant thunder and then a shaking and reeling of the ground that was quite fearful, accompanied by the noise of falling tiles., accompanied by a loud shout from the city which was quite audible here at a distance of a mile. I cannot tell you what were my own sensations on feeling the solid earth reel as a drunken man.

From this time till half past twelve we had six severe shocks and they continued until six in the morning. The residency is sadly injured-the whole of the upper story is nearly gone. R's house is rendered uninhabitable, and even mine which is a pukka one of only one story, has got some awkward cracks in many parts of it. An elephant house, cook rooms and other small houses are much injured, and we want but a few more shocks to bring our houses down. No lives have been lost on the residency grounds, but it is otherwise at Catmandoo, Patna [*Patan/ typo*] and other towns in the valley. The loss of life is not yet ascertained, but they say 25 in the former, and 30 in the latter town. In both towns several houses have been leveled with the ground, and a large temple of Juggernaut, which had been formerly injured by lightning but was near an immense mass of pukka buildings, came down this morning by the run, and presents nought now by a mountain of bricks. The houses of many chiefs in the city have suffered much, and two pillars, each about 100 feet high, built by the minister, and his nephew some years since, are now no more. The city is at present quite deserted, the Rajah having ordered every man to vacate his house and take to the fields for two days. Fair ones, who till last night had never seen the light of heaven, save through a purdah, were bundled *sans ceremonie* into the open air, and all in all it is a fearful state of things. I trust it is over for the present, but we are in doubts, for the last great earthquake here in 1829 continued for many days, and even at this sitting a slight shaking of the ground is perceptible.

Letters continue to arrive from all parts of the country especially from the north and west, giving accounts of the effects of the earthquake, some of which seem to have been of most serious character, involving destruction of life and property. It does not appear however, as far as our information at present extends, that the calamity has been so heavy as was a similar visitation in 1829, - while in comparison with the earthquake in 1762, it has been extremely mild and innocuous. On the last occasion the rivers and tanks throughout the country were strongly affected- the waters rushing with violence and rising in some places ten feet perpendicularly, and continuing in agitation for a quarter of an hour at a time. At Dacca five

hundred people were killed- at Chittagong the earth opened in many places; quantities of water gushed out, great chasms remained unclosed, reports underground were heard, and many buildings were thrown down. Near Luckipore, a circuit of land, about 15 miles in circumference, was swallowed up, and all the inhabitants and cattle perished. Nothing equal to this has occurred now.

(The India Gazette, Calcutta, Monday 9 Sept. 1833, III, 869, reprinted from *John Bull*)

KATMANDOO Aug. 30-

X

On the 26th at 11 o'clock P. M. we had a serious shock of an earthquake, which is calculated to have destroyed 8-10,000 houses, and 6-800 souls in the several towns of the valley, and to have done extreme mischief beyond its limits Eastward. The direction of the motion was NE and SW and its character, undulatory, with a very long swell and roll. The great shock was preceded, 5 hours, by a lesser one; and has been followed by innumerable trivial vibrations which have not yet ceased.

(The India Gazette, Calcutta, Tue. Sept. 12 1833 III, 872., reprinted from the Bengal Hurkaru Wed. Sept. 11 XII(63) New Series)

KATMANDOO Aug. 30-

"Further accounts have been received from Nepal describing the terrible effects of the Earthquake of August at Lassa, where the destruction of lives and buildings has been greatest. The particulars, we understand, will be given in the *Journal of the Asiatic Society*. A late number of the *Mofussal Ukhbar* has a long article upon the last earthquake in which reports are given for a great many places, shewing pretty accurately the extent of its influences. The writer concurs with the author of the article in the *Journal of Science* in tracing the seat of the disturbing cause to some unknown spot among the Himalaya mountains. A fact is mentioned in the Chupra Report which merits the attention of our Geologists if true, but which we should not hesitate to believe without further details, namely that the earth opened, and a chasm of some depth was formed about two miles from that place'.

(The India Gazette, Calcutta, Sat Oct. 6 1833 III, 892, reprinted from the *Calcutta Courier*.)

[note: The *J. Asiatic account* is Prinsep's p.438 in the August edition, and the *Mofussal Ukhbar* reference may refer to the Sept. 14. edition above that may contain more details than printed in the India Gazette. The comment about Chupra above refers to the entry in the 6 Sept. India Gazette, III, 867, last paragraph on Chupra. Campbell is adamant that no damage occurred at Lhasa, and may have been prompted by the above news report to be emphatic about this in the November edition of *J. Asiatic Soc.*]

LUCKNOW 27 August

VII

It may be interesting to your readers to learn that last night (the 26th instant) the city of Lucknow was visited by 4 shocks of an earthquake, the first about sunset, the others between 11 and 12 P.M. The tremulous motion of two of the shocks resembled the motion felt in a steam vessel; the rocking caused the beams of the houses to creak, the lamps to swing to and fro, and in one house fragments of cornice to fall. In the stillness of midnight, superadded to the knowledge that the scourge of Cholera Morbus was now fearfully active throughout the city, there was something very awful in the sensation, and as the earth rocked and the walls moved, I almost expected to hear the crash of some falling building.

(The India Gazette, Calcutta, Tue. Sept. 12 1833 III, 872, reprinted from the *Mofussal Ukhbar*, Aug. 31. 1833)

LUCKNOW

VII

On the night of the 26 th August an Earthquake was felt here, some people felt several shocks, one about sunset. I felt only the last which must have been the most severe. It awakened all out of our sleep at half past eleven at night and lasted about 2 or 3 minutes. A servant of mine who thought the house was coming down ran across the compound to his own house, and fell down three times on the way, the ground shook so much.

(The India Gazette, Calcutta, Wed. Sept. 18 1833, III, 877 and in Bengal Hurkaru Fri. Sept. 20)

MEERUTT

V

Earthquake.- Meerutt was visited on the night of Friday last by the smart shock of an earthquake It continued for about 15 s, but was not severe enough to do any mischief We have received further accounts

of damage done by the late earthquake in the country immediately above Benares. The tract lying between the Ganges and the hills seems to have been most severely visited; details have however been published in the Calcutta newspapers.

The India Gazette, Calcutta, Oct. 10 1833 III, 896 and in the Beng. Hurkaru and Chronicle Mon. Oct. 7 5786 Old Series reprinted from *Meerutt Observer* Sept. 26

MALDA 4 Oct. 1833 aftershock

V

We had a severe shock of Earthquake yesterday at 08:10, which set the punkah swinging and venetians rattling in a fearful style. Malda Oct. 5 1833

(The India Gazette, Calcutta, Oct. 10 1833 III, 896)

MONGHYR 27 Aug. 1833

VIII-IX

Sir. - Five shocks of an earthquake were experienced last night and this morning at this station. The first occurred 5 minutes after sunset, the second at 11:25, the third at midnight, the fourth and the fifth at 03:45.

The second and third were most severe and have caused considerable damage to the houses in the town of which about 34 have been more or less injured by the falling of balustrade and balconies or cracking and separation of the sidewalls and beams.

Mr. Hamilton's house has suffered severely, and the beams of the verandah are all loosened from their sockets in the walls, and many feet of plaster cracked and torn off; the walls having been also much shattered.

At the third shock the inmates of my house all alit and passed the rest of the night in a temporary covering made with bamboos and a suttrinee. The lamps were all extinguished by the trembling of the walls, the clocks stopped, and the glasses of the sideboard knocked together, and made with the agitation of the jhilmils, and rumbling underground which accompanied the earthquake, a frightening noise.

The direction of the shocks appeared to take was from the NE to the SW. This circumstance was manifest from the noise made by the natives as the shock passed along. The people continued shouting and drumming the whole night, I suppose to propitiate the causes of this awful visitation.

I am unable to speak with any certainty of the duration of the shocks, but from what I have heard and from my own recollection, the first appeared to last about 30 seconds, the second and third about a minute each, after which there appeared to be a trembling motion in the earth for about half an hour, and the glasses in the sideboard continued during that time to shake.

Colonel Bird's house has sustained considerable damage and his family have been obliged to leave it altogether. They took refuge during the night in some tent which has been pitched during the day to be aired.

Considerable portions of the ramparts of the Fort have fallen down; I observed two places in my mornings ride to the extent of about 20 yards in breadth and 30 in height. These walls are made of brick and mortar cased with stone. I heard that there were two other parts of the wall that had been thrown down.

Mr. Page's house and Captain Watson's were also, I heard, much damaged. In my own the outer walls on the East and West sides are cracked in several places, the fissures going quite through the walls.

There was no particular change in the river that I am aware of, but the shocks were distinctly felt by people in boats. One gentleman I met this morning said he thought at the time that a violent storm was coming on from the agitation of the water and the motion of the boat, but finding the true cause from the people on the shore he deemed it prudent to leave his boat.

So general was the consternation caused by this unusual event that nearly all the Europeans and other inhabitants of puckah houses resident in and about the fort left their domiciles and sought refuge in the meidan.

Yesterday was a particularly hot day, and the evening sultry and unpleasant. To-day we have much the same kind of weather, but the horizon is surrounded by heavy lead-colored clouds, and there is lightening in all directions.

Since the last shock above alluded to, partial and slight tremblings of the earth have been experienced the whole day.

The commissioner's house is situated upon the highest spot at the station, but has not suffered in the least; the earthquake, however, was severely felt there. Since writing the above another slight shock occurred at half past nine P.M.

Yours faithfully, A Resident.

The India Gazette, Calcutta, Thursday Sept. 5 1833, III, 866, reprinted in Bengal Hurkaru and Chronicle XII(59New series) Mon. Sept. 9 1833

MONGHYR Aug. 27

VII

This station was visited by an awful calamity: a constant succession (about 30) of awful shocks from 17:00 yesterday until 08:30 today, of which some were so severe as to destroy several fine houses and materially injure others. The whole population of Monghyr spent the night in the open air, and we much fear that this place is the focus of volcanic matter, and that the present is but the forerunner of a still more severe visitation. (Bengal Hurkaru and Chronicle XII(58)New series) Thu. Sept. 5 1833 reprinted in The India Gazette, Calcutta, Friday Sept. 6 III, 867.)

MONGHYR 27 Aug. 1833

VIII-IX

We were last night visited with one of the most awful calamities that has ever been known in this place. A succession of 7 shocks of Earthquake from 17:00 till 08:30 this morning, in which many fine houses have been injured and some totally destroyed; amongst the later is Mr. Graham's fine house, which was rented on a lease to Lt. Col. Bird. It was truly awful to hear the cries of the people and crash of houses falling, the ringing of bells, the beating of tom-toms, the Musselmans at prayers, and all the populations of Monghyr, of every description, out in the open air; the ground every five minutes shaking and trembling in a frightful manner. Mr. B. and family were obliged to fly for their lives, and come over to mine; several others did the same and amidst the horror and dismay of all around we spent the night. There were upwards of 25 shocks during the night, and 5 after day break.

(The India Gazette, Calcutta, Monday 9 Sept. 1833, III, 869, reprinted from Bengal Hurkaru, XII(60), Sat. Sept. 7 1833.)

MONGHYR

A letter from Monghyr mentions that shocks of earthquake were felt there up to the 29th ultimo" and a letter from Mullye, which we publish shows that they were felt there up to the 31st [August] inclusive. We are much obliged to correspondents who have favored us with such accounts. they will doubtless be of use, as has been suggested, in preparing a connected statement of all the phenomena.

(The India Gazette, Calcutta, Wed 11 Sept. 1833, III, 871.)

MONGHYR 2 Sept. - Mon. 26 Aug. Earthquake VIII

Several Pucka houses in the town have sustained injury, and all are more or less cracked. I observe that the houses most damaged are those that have new buildings attached to the old - the same is the case with houses in the Fort I hear that all the clocks at the station stopped at the second, or severe shock.

Calcutta Courier Sept. 11 reprinted in Bombay Courier XLI 2277

MONGHYR 12 Sept. 1833

You would no doubt be surprised at my last, how much more you will be astonished to learn that the earthquake mentioned in that has not entirely left us, we have had numerous shocks since the first, but of no great magnitude and perhaps they have added more fear than that to real injury, but certain it is the earth has never been 5 minutes perfectly steady since the 26th of last month, and from the continued tremulous motion, many are fearful that it will end some dreadful catastrophe.

(Bengal Hurkaru and Chronicle Sat Sept. 21.)

MORSHEDABAD zilla 30 Aug. 1833

V

We were visited on the 26th with several smart shocks of earthquake; the first about 1900 was but slight, but two others about midnight, within about ten minutes of each other shook the house awakened the birds and caused the hanging lamps to vibrate for 20 minutes after - so severe was the last shock, that I feared the

house would be injured. The earth trembled so violently that it was difficult to keep one's leg. The natives in their frail tenements felt it severely for the neighbouring villages resound with their "Hurribole, Hurribole". reprinted in Bengal Hurkaru and Chronicle, XII, 59 New Series, Mon. Sept. 6 1833, from John Bull.

MULLYE 27 Aug.

V

You will doubtless have numerous accounts of the earthquake which occurred last night at this station. The first shock, which was very slight, took place at 18:30. At 23:15 we had a very severe shock, and about 23:45 another which continued whilst I deliberately counted 350, for I had no watch by me to time the shocks; some seconds must have also elapsed previous to my commencing counting. From this period until 03:15 we had a succession of slight shocks, in all 16 in number, and at 06:00 a seventeenth. They ran in a direction from north to south and the vibrations occasioned by the second and third were particularly violent, very nearly, if not quite as violent as the great Earthquake in 1803. Meteorite at 3 am. Your obedient servant, The India Gazette, Calcutta, Friday Sept. 6 1833, III, 867, reprinted in Bengal Hurkaru, XII(60), Sat Sept. 7 1833.

MULLYE 30 August 1833

Since the first night of repeated shocks at Mullye we have experienced several slighter successions, on each succeeding day and night, up to this date.

(The India Gazette, Calcutta, 1833, Monday 9 Sept. 1833, III, 869, reprinted from the Bengal Hurkaru. Tue. Sept. 10 1833 XII(62) New Series)

MULLYE 1 Sept. 1833

V

I mentioned that we had no less than 17 shocks of Earthquake at this station during the night of 26th up to 6A. M. ultimo. In the course of that day two other slight ones occurred and two more from 9 to 10 PM. On the 28th at 16:15 we had a very smart shock, the vibrations of which lasted for about a minute. On the 30th at 11:30 a slight one; at 01:00 this morning a shock; at 06:00 another shock. Numerous other tremors of the earth have been experienced, but we have become so accustomed to the sensation, that it is difficult to divest ourselves from the idea of the shaking, and it is only when assisted by the other senses, and that when we perceive the flapping of doors, and moving of punkahs &c, that we are satisfied we are not under a delusion.

(The India Gazette, Calcutta. Tue Sept. 10 1833, III, 870)

NORTH TIRHOOT Aug. 27 1833

VIII (North of Muzaffarpur)

This part of Tirhoot was visited a 18:00 yesterday by a severe shock of an earthquake, which began with a motion from east to west, and which was repeated at 11 and 12 with double violence continuing throughout the night until 6 this morning. The two shocks in the middle of the night were most awful, lasting I should think, each time more than a minute. The bungalow in which I reside was violently shaken, rocking to and fro, the doors and wall shades were equally agitated, and the walls were rent in many places. Had the successions towards morning been equally violent, I fear my bungalow would have been in ruins.

The walls of my press house and drying house were opened in several parts and the water in the reservoir 4 feet deep, and 3 from the surface, was so much agitated as to fly over each side. At one time I thought all was going to rack and ruin.

I have been in India many years, and I have never experienced anything half so awful as the shocks during the night. In 1818 [Probably Cutch earthquake 1919] if I remember right, a severe shock was felt in Calcutta, but nothing equal to last night.

(The India Gazette, Calcutta, Monday 9 Sept. 1833, III, 869)

NUSSEERABAD (Nasirabad 24°26', 90°)

I

"No mention is made of the earthquake".

(The India Gazette, Calcutta, Sept. 26 1833 III, 884)

PATNA 28 August

VIII

But now we have recovered from the horror of the event I have to communicate of an Earthquake which has alarmed us exceedingly. Its first access was 18:30 on the evening of Monday, and I distinctly felt the shock, but as I was not supported by any observation of similar tendency, I began to think it must have been fancy. About 23:30 I was awakened by a horrid rattling and shocks apparently from the E. to W. with a rumbling noise, the servants running into the room in great consternation, when the whole truth flashed upon my mind. This was the first of two very severe shocks, the last of which occurred at midnight, and the oldest inhabitants here say, that a severer one they never remembered. It is quite impossible to describe the horrors of these two shocks. I have faced a good deal of nature's wildest wrath, the wrath of the Ocean and storm and tempest, and in both I have seen the hand of God in death - and other visitations, but these were indeed "the terrors of the Lord". Several houses at BANKIPORE have been cracked by the earthquake, amongst which are the Magistrate's Kutchery, and in the city, the Opium godown has shared the same fate as well as the great gateway built by Maha Rajah Metre Jeyt Sing, while many of the pukka native dwellings have bodily fallen. At DINAPORE the former Brigade Major's house was split and also some houses between Patna and Diggah.

18 shocks were counted by some, but they appeared continuous. The last was at 08:00. Almost all the inhabitants left their houses during the continuance of the shocks and remained out the whole night. (The India Gazette, Calcutta, Monday 9 Sept. 1833, III, 869, reprinted from Bengal Hurkaru, XII(60), Sat Sept. 7 1833.)

PATNA 27 Aug. 1833

VIII

Last night at about 23:00 we had a most severe shock of an earthquake the like of which I have not witnessed or heard of, it came on at four different times, and the shock was so very great that the whole of Patna appeared as if floating and a great number of houses fell, and various sorts of injury sustained. Rajah Khan Behadoors Stable fell by which seven of his horses died.

The outer wall of Captain Elliots house was also leveled with the ground. Mr. E.D'Costa's house is also cracked in several places and a few of his wall shades fell to the ground. Many of the gentries have suffered considerable injury to their property. The alarm was so great that the inhabitants left their house and stood out in the compound with their family the best part of the night. The shock was most dreadful and alarming, we every moment expected to be our last.

(The Bengal Hurkaru and Chronicle, New Series XII, 57, New Series 4 September 1833 Calcutta)

PURNEAH 27 August (now Purnea)

IX

This place I am sorry to say has been visited by several of the severest shocks of earthquake within living memory of the oldest inhabitant. The following is as correct account of it as I was able to preserve:

- 1st shock at 17:30 26 Aug. 1833 rather slight
- 2d 23:00 severe
- 3d 23:18 most violent
- 4 23:28 slight
- 5 23:32 ditto
- 6 23:46 ditto
- 7 01:00 27 Aug. 1833 ditto
- 8 03:25 ditto
- 9 05:52 ditto
- 10 08:00 rather severe

So great was the undulation, that birds of every description were driven from their nests, men were scarce able to keep their feet, and the cattle running about wild with fright. During this severe shock, several old buildings in the town tottered to pieces, and part of one of the stations actually partially sank. A heavy cornice of a newly erected wall in a gentleman's bungalow came bodily down and literally smashed a table and some chairs to pieces: every building has suffered more or less. A recently vacated upper-roomed house has not an arch left; large masses of bricks have fallen out; the roof in many places slipped and the beams and burgahs separated by an inch or more; the outhouses in this compound are a heap of ruin.

I am led to infer from the stoppage of a clock and other testimony that the undulation came from the southward and traversed east. During the 3rd and severe shock a heavy rain fell to the south accompanied by

much wind. I have not time to particularise further. You will be glad to hear that no lives have been lost, at least, I have heard of none, and I trust I shall not.

(The India Gazette, Calcutta, Friday Sept. 6, 1833 III, 867, reprinted from the Bengal Hurkaru and Chronicle XII(58) New series, Thu. Sept. 5 1833)

PURNEAH 27 Aug. 1833.

VII

The earthquake seems to have been felt there as elsewhere on the night of the 26 th: no less than 14 or 15 shocks were experienced - two of them which took place between 23:00 and 24:00 were very severe, and appear to have done a good deal of injury to several houses of the station.

(reprinted in Bengal Hurkaru and Chronicle, XII, 59 New Series, Mon. Sept. 6 1833, from John Bull)

PURNEAH Oct. 11 1833 (aftershock)

The 4th Oct. shock at this place though not severe was sufficiently so to be duly appreciated. Upon the testimony of a gentleman whose premises lay not 5 miles of the Nepal boundary, and who was at the time shooting on his grounds, I learn that immediately anterior to the shock, three distinct reports similar to the discharge of heavy artillery were distinctly heard followed by a slight and jerking vibration, which instantly assumed an extraordinary undulation, corresponding with the rise and fall of a heavy swell at sea..... in the villages of Furkeah and Shanore..... Yours obediently, A reader.

(Bengal Hurkaru, and Chronicle, Sat Oct. . 16 XII(102).)

ROTAS HILLS Aug. 28 1833

IV

At 23:10 on 26th instant, just about falling asleep, felt my bed shaking and the roof the bungalow creaking; an earthquake says I, and got out of bed immediately, and entirely out of the house? Not a soul near but a chokedar who seemed just to have awoke. I asked him if he felt the earthquake shake, he said he thought the house shook, but it was owing to wind, of which there was only a light air from the NW.- a pretty bright moon; this shock lasted not more than a minute I believe; went to bed again, and lay watching, when a second rocking came on, and at 23:28 it came on again, sure enough much more severe and of much longer duration - I really think of not less than 2 or 3 minutes. I lay quiet some seconds to be certain it was not the effect of fancy, but it became too palpable; the roof of the house was creaking, and the lamp swinging 2.5-3 inches each way.

Bengal Hurkaru and Chronicle, XII(59), New Series, Mon. Sept. 6 1833

RUNGPORE 27 AUGUST 1833

V

We had last night three Earthquakes. The first a little after sunset, very short. The second at half past eleven, very strong and it lasted about thirty seconds or more. The third was still more severe and of forty seconds' duration. Unlike those in July they began gently and went on fearfully increasing to near the end.

(The India Gazette, Tuesday Sept. 3, III no. 864)

TIRHOOT (*Muzaffarpur region*) Sept. 5 1833

IX (?X)

Then comes the 26th-the awful earthquake of which you no doubt ere this had better accounts than I can pretend to give; however, with your permission I will state how I felt myself. At 6:30 there was a slight shock; again at a quarter past eleven I was aroused from my slumbers by a violent shaking of the bed under me, and immediately conjectured what was going on, and made a precipitate retreat to the *maidan* fully expecting the house would be down before I was out of danger. This shock passed over in a short time, I should say it lasted a minute, and I again turned in, and was just on the eve of falling asleep, when came another edition far more severe than the preceding, which again sent me flying or rather staggering, for I certainly found it difficult to retain my gravity. To give you some idea of its tremendous force, I will merely mention the circumstances of my reservoir which was full, having had the water thrown out to the depth of two feet and a half North and South, by the vibration. The damage done to the Pucka buildings and bungalows in the district is considerable, but no doubt still more so at Patna and such like large cities, where the houses are built of frail materials from economy, and shew being the chief object without regard to stability. We have repeated shocks (slight ones) every day since; a very perceptible one yesterday at 3 P. M. and what the end of it all may be a subject of speculation. A gentleman on the border of the Nepal

Terrai writes, that he expects on getting up some of these mornings to see a splendid volcano burning on the top of the mountains. What an addition this would be to their already majestic appearance!
 (The India Gazette, Calcutta, 1833, Wed. Sept. 18 1833, III, 877 reprinted from the *Bengal Hurkaru*)

TIRHOOT (*Muzaffarpur region*)

?IX

The earthquake was very grand here, and equally so all along the Terai, doing great damage of course. Accounts from Nepal speak of it as awfully sublime at Khatmandoo, the earth rocking like a raft on a rough sea: houses, temples, walls, all tumbled about and many lives were lost. The poor people were driven out for safety into the fields, and the shocks continued at long intervals on the 27th, 28th and 29th.-
 (The India Gazette, Calcutta, Sept. 26 1833 III, 884, reprinted from *Mofussal Ukhbar* Sept. 14.)

Prinsep, H., (ed) J. Asiatic Soc. of Bengal , 2, Miscellaneous, IX, 438-9, August 1833

Note: Text assembled by the editor (H. Prinsep) from newspaper reports and A.C. (= Dr. Archibald Campbell, Assistant Surgeon to the British Legation to Kathmandu). The times are given for the second shock, not the mainshock, and were used by Mallet 1852, however, Mallett was mistookr of the locations of the Rothas Hills (S. of Patna), Bankura (N. of Calcutta) and Mallai. Prinsep cites Mullye as Mallai. Campbell indicates the Kathmandu time of the second shock as 22:45 which is significantly earlier than times listed from other locations. On page 564 of J. Asiatic Soc. the editor revises the Kathmandu time difference here entered as 12 minutes to 51 minutes to yield a Calcutta time of 11:36.

IX. Earthquake of the 26th August

The daily papers have published notices of this phenomenon, as observed at a great many places in the interior of India, with more or less detail, from which the following general facts may be gathered:-

The direction was from NE to SW: there were three principal shocks; the first about 18:30, the second at 23:30 and the third at 23:55 (Calcutta time). In the places where it was most felt, slight and continued vibrations seem to have been experienced for the whole day following. As the time of the second vibration was accurately noted in Calcutta by the stopping of an astronomical clock., we may assume it as the best point of comparison with the times noted at other distant points. A few of them may be thus classed.

	Observed h:m	Diff. Long m.	Cal. Time h:m	
Katmandu, Nipal, second shock	10:45	+12	10:57	very severe, loud noise
Rungpur, ditto	11:20	-2	11:18	many houses injured do.
Monghyr, ditto	11:27	+7	11:34	walls cracked, noise heard
Arrah, ditto	11:15	+14	11:29	walls injured
Under Rotas Hills ditto	11:10	+20	11:30	
Gorackpur, ditto	11:20	+19	11:39	walls cracked &c.
Allahabad (vague) ditto	11:00	+28	11:28?	hollow sound from river
Bankura, ditto	11:30	+4	11:34	none such since 1814.
Calcutta, ditto			11:34:48	no injury done

At Monghyr, Rungpur, Muzefferpur, Mallai, and other places within the direct line of influence, many houses were destroyed or injured, and the alarm was great. At Katmandu, the following extract of a letter from Dr. A. CAMPBELL, dated the 28th inst. will shew that the consequences were more serious, and judging by the course of the phenomenon we may reasonably fear some dreadful catastrophe towards Lassa on the north of the great Himalayan range.

“ On the evening of the 26th, about 6 o’clock, the valley and neighbouring hills were visited by a severe shock of an earthquake: it lasted about 40 seconds, and during its continuance, there was a distinct audible noise as of an ordnance passing rapidly over a drawbridge. It seemed to come from the east, and I felt that it was traveling with the speed of lightning towards the west, and just under my feet: the houses shook most violently, and trees , shrubs and the smallest plants were set in motion,

not shaking but waving to and fro from their very roots. No damage was done to life or property. At 22:45 we had a similar shock in brevity and duration, and at 23:00 a most tremendous one. It commenced gradually, and increased until the houses, trees, and every thing on the face of the ground seemed shaken from their foundations. The earth heaved most fearfully, and when the shock was at its worst we heard the clashing of falling tiles and bricks in every direction; and to add to the impressiveness of the scene, a general shout rose from the people in all directions. The murmur of human prayers was carried audibly from the city to our grounds (a mile), and nothing could be more imposing and vast than the scene. In a dead calm the noise of a hundred cannon burst forth: full grown trees bended in all directions, and houses reeled about like drunken men. In our grounds no lives were lost, but in Katmandu 19 persons were buried under the ruins of their own houses, and in the towns of Bhatgoan and Patan, many more. The great shock continued for nearly a minute, and during the following hour there were six distinct and strong shocks, the ground in the intervals between scarcely, if at all steady; and from this time till yesterday morning there were upwards of 20 distinct and sharp shocks. The loss of property has been very great, 125 houses fell in Katmandu during the night of the 26th, and nearly as many more have been levelled with the ground. Up to this time, in consequence of the torrents of rain that have come down, finishing the work of destruction commenced by the earthquakes, the city and town have been evacuated, men, children, and women of the *purdah*, rich and poor have been and still are on the plains about the towns. Innumerable temples have been destroyed, and the very gods of them have been crushed to atoms. A fine and large brick temple (100 feet high), built in imitation of the great one at Jagarnath, came down by the run early yesterday morning, and two fine pillars by BHIM SEN were demolished by the shock. All yesterday and last night we had occasional small shakes, but none equal to the great one we had on the 26th.”

A subsequent note from the same gentleman, dated the 30th instant, gives further particulars of this disastrous event:-

“We still continue to be visited by occasional shocks of earthquake, all less violent than the great one on the 26th, but sufficiently alarming. This morning when at breakfast, we had a rather sharp one: they all seem to come from the same direction; that is from the east and north-east. The places east of Katmandu have suffered most: Bhatgaon, a large town, has been almost entirely destroyed; upwards of 1000 houses have been levelled with the ground, and few have escaped serious injury. 300 souls have perished in this town (Bhatgaon) alone, and the total number of lives lost throughout the valley, as yet ascertained, is estimated at 500. The unfortunate people in many instances are in sore distress; their stores of grain being buried beneath the ruins of their late dwellings, and without money to purchase other food. The grain shops, as well as all others are shut, and the people dare not return to their houses but remain without sleep or shelter in the open air, under torrents of rain. The house of MATABAR SING (a goodly modern mansion) is quite destroyed, and the large garden houses of BHIM SEN, and his brother, RAU BIR, are rendered, for the present untenable. Scarce a large house in Kathmandu has escaped injury. The fort at Chisopani, on the road to this from the plains, is much injured, and almost all the Government buildings have sustained great injury.”

A.C.

Campbell, A., J. Asiatic Soc. Bengal Vol. 2, 564-565, November, 1833

II. Account of Earthquake at Kathmandu. By A. Campbell, Esq. Assistant Surgeon, attached to the Residency.

On the 26th August last, about 18:00, a smart shock of an earthquake was experienced throughout the valley, and the neighbouring hills, westward in the valley of Nayakot and Duny Byas; eastward at Panouti, Banepa, Dulkele, and Pholam Chok; and southward at Chitlong, Chisagarhy, Etounda and Bissoulea. The shock was preceded by a rumbling sound to the eastward. The motion was undulatory, as of a large raft floating on the ocean, and the direction of the swell was from NE towards the SW. The shock lasted about 1 minute. At 22:45 (footnote:Not by chronometer, but by a good-doing clock, which stopped during the great shock. Its pendulum vibrated north and south. [If the clock was set by the sun, the shock must have been 51 m. earlier than Calcutta. Ed.]) of the same day

another shock of equal duration and of the same character occurred, and at 22:58, a third and most violent one commenced: at first it was gentle rocking motion of the earth, accompanied by a slight rumbling noise: soon, however, it increased to a fearful degree, the earth behaved as a ship at sea, the trees waved from their roots, and houses moved to and fro far from the perpendicular. Horses and other cattle, terrified, broke from their stalls, and it was difficult to walk without staggering as a landsman does on ship board. This shock lasted about 3 minutes in its fullest force. And the following is as correct an estimate as can be ascertained (without official documents) of the damage done by it to life and property throughout the great valley and neighbouring districts of Nipal. It is believed that the first two shocks were harmless.”

[Dr. Campbell’s subsequent letters inform us, that there have been frequent shocks of less violence since the above, many of which (on the 4th and 18th Oct. particularly) were felt at Calcutta, Monghyr, Chittagong, Alahabad, and Jabalpur nearly simultaneously. On the 26th (Sept.) he writes, “At 10:45 a sharp shock of the dangerous or undulating kind occurred. The embassy has returned from China, and I am informed that the great shock was not felt in Lassa, so that it would appear to have been confined to India within the Himalaya.” Ed]

Number of Lives Lost and Buildings destroyed:

named location	inferred location	killed	wounded	houses
British Residency grounds		0	0	1
Kathmandu.		60	38	400

Two pillars, built by the minister, each upwards of 100 feet high, the large Temple of Jagarnath, built by Ran Bahadur, after seven years labor, and about a dozen temples destroyed. The modern built garden houses of several members of the ministers family have been rendered untenable, one of them a handsome and ornamental edifice has come to the ground.

South of the Capital

Patan	Patan	27 39 85 19	6	25	285
Sana goan	Sanagau	27 38 85 22	0	0	40
Harra Sidhi	Harisiddhi	27 37 85 21	0	0	20
Teshu goan			0	0	25
Selli goan			0	0	16
Pagah	Panga	27 39 85 16	0	0	24
Kuknah	Khokna	27 37.5 85 18	1	0	130
Baghmati.	Bungamati	27 37 85 18	0	0	80

A crack in the ground of 20 feet in length was observed at this village on the morning of the 27th; the entire number of houses in it was 206, more than a third of the whole were destroyed, and about 100 men [*more?*] have been much damaged. The injury sustained here is probably greater than in any other part not to the east of Kathmandu.

Phurphing	Pharphing	27 36.5 85 16	0	0	8
Chappa goan	Capagau	27 36 85 19	0	0	35
Peang	Pyanggau	27 35 85 19.5	0	0	8
Taibu	Thaiba	27 36.5 85 21	0	0	18
Bara goan	Baregau	27 36 85 21.3	0	0	35
Bali			0	0	3
Pahon			0	0	3
Sassanelly	Sisneri?	27 37 85 24	0	0	2
Lubu	Lubhu	27 37 85 22.5	0	0	25
Sana	Sanagau	27 38 85 22	0	0	7
Hills about Sassanelly		27 35 85 24	0	0	20

E. of Kathmandu in Valley

Deo Patan.	Deupatan				3 0
Temple of Paspatnath	escaped unhurt.				
Handi goan			0	0	20

Nag Desa	Nakdes 27° 40.5' 85° 23'	4	0	20
Bareh	Bore 27° 41', 85° 23'	5	0	20
Temi	Thimi 27° 40', 85° 23'	0	0	150
Gou Karan	Gokarna 27°44', 85°24'	0	0	8
Changu.	A fine old temple destroyed.	0	0	20
Sankhu.	Sakhu 27 43 85 28	20	5	45

A handsome temple of Mahadei, situated on a hill above Sankhu is reduced nearly to ruins.

Bhat Goan	Baktipur 27 39 85 26	200	104	2000
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(Total number of houses in Bhat goan is reckoned by Mr. Hodgson at 4700, 3/4 th of the town said to be destroyed, 2000 is the average of many accounts, 6 or 8 fine temples destroyed, and a statue of Rajah Ranjit Mall, one of the Newar Princes of the Bhat goan division of the valley)

E of Kathmandu beyond valley but nearby

Sangu	Sanga 27 38 85 29	2	0	8
Banepa	Banepa 27 37 85 32	10	0	20
Nala goan	Nala	6	0	11
Panouti	Panauti 27 34 85 31.5	18	0	19
Dukele	Dhulikhel 27 37 85 35	10	0	21
Phulam Chock	(A fine temple destroyed here) ? Palanchock	60	0	300

NE of the Valley

Dhulaka	Dolacka 86.1, 27.7			
Listi gaon	Listikot 85.954, 27.89)	0	0	0

Mundun Pahar, Kassa (Darm=Khasa, 85.95, 27.00), Kuti. In this direction the earthquake was much more severely felt. **Kuti**, a town on the Bhote frontier on the road to Lassa, is said to have been nearly destroyed, it contained 600 houses; 50 of which only remain. At **Listi gaon**, (?Listikot) also on the Bhote frontier, a large portion of hill came down, and an iron bridge was destroyed. At **Kan Sing Choke** (?Choksum 86.00, 28.07), in the same direction, vulgar report says, that for 5 days before the earthquake took place, noises similar to the firing of cannons were heard as if underground: and in this neighbourhood the high road to Lhasa is said in many places to be blocked up by the fallen earth from the mountains. **Shipa**-the country residence of Colonel Runbir Sinh, 20 miles from Kathmandu on the Lhasa road, by the Kuti Pass, is seriously injured. Many small houses attached were destroyed and several lives lost.

W. of Kathmandu

Swambunath.	Swayanbhunath 27 42.3 85 17	0	0	3
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One small temple destroyed, and the large one a little injured. The form of the large one must have preserved it. It is the chief budhist temple in the valley, built in the fashion of that religion - an immense circular mound of brick work, surmounted by a 4 sided spire or jweet.

Hal Chok	Dahacok 85 27, 27.72	0	0	3
Narod Devi		0	0	1
Changu Narayan		0	0	2
Goorkha Cantonment or Campoo.	House of the Captain much injured	0	0	4
Kirtipur	Kirtipur 27 40 85 16.5)	0	0	14

Contains 532 houses, and is built along the ridge and brow of a hill 3900 feet higher than the surrounding part of the valley. Its tenements are old and frail.

Thankote	Thankot 27 41 85 12.5	0	0	23
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W. of Kathmandu Valley

Duny Byass and neighbouring hills		10	0	40
Tewanpur		0	0	10
Nayakothe	Nuwakot	0	0	3

North of Kathmandu

Dharmtuli	Dharamtali 27 45.5 85 18	0	0	2
Hukin gaon		0	0	1
Toka gaon	Tocka 27 45.5 85 20	0	0	15
Burba Nil Kanth	Burhanikanth 27 46 85 21.5	0	0	2
Chapaly	Capali 27 45.5 85 21.5	0	0	7
Dharmpur	Dharmapur 27 44.5 85 20.5	0	0	20

South of the Valley

Chitlong	Chitlong 27 40 85 11	0	0	14
Chisapani	Chisapani 27 32 85 10	0	0	0
The fort here much injured: a large portion of breastwork facing the south has fallen, and the wall in many other places, although not fallen, is seriously injured.				
Mukwanpur	Mukwanpur 27 25 85 09	0	0	0
The fort here has also suffered, but in much less degree than the fort the one at Chisapani.				
Total		414	172	4040

The above shews that the earthquake was much more severe to the N and E of the valley than here; and that even within the valley it was much more violent to the E of Kathmandu than at the capital itself, or other places to the west of it. The town of Bhat gaon is not more than 8 miles in a straight line from Kathmandu, and even there its violence must have greatly exceeded what it was at the latter place. To account for the immense disproportion in the loss of life and property at both places, something may be allowed for the more frail state of the buildings at Bhat gaon; but this is not sufficient, and this circumstance must be considered as inexplicable as most others attending this fearful phenomenon. The brahmans of Nipal say (and it is believed with truth) that the occurrence of a more violent earthquake than this is recorded in their histories. It was about 600 years ago, and then the cities of *Mangah, Patan* and innumerable other towns were utterly destroyed and thousands of their inhabitants killed: the modern capital Kathmandu did not then exist.-

Campbell, A., Further particulars of the earthquake in Nepal. J. Asiatic Soc. Bengal, VI, 636-639, Dec. 1833

In pursuance of the attempt made before to note the destructive effects of the earthquake of the 26 th August last, throughout the valley of Nepal, and its immediate neighbourhood, and with the hope of shewing as correctly as my information will permit, the probable seat or center of this commotion, I beg to offer the following memoranda of other places at which the shock was experienced, as well as its comparative degree of intensity at each.

The means of estimating the violence if this phenomenon are of course most defective, if not wholly inadequate to the purpose: but in absence of better data, the ascertained amount of damage done to the frail and perishable works of man, may be received as an index of its intensity at one place, compared with that of another, and in conformity to this mode, it would appear that the most extreme violence of the shock, as far its occurrence is yet known, was expended in the tract of country extending from this side of the great Himalaya range on the north, to the course of the Ganges on the south, and from the Arun river (in the Nepal hills) on the east, to the eastern branches of the Trisul Ganga on the west, comprising a space of about 200 miles from north to south, and 150 from east to west. In this space, the valley of Nepal, though not geographically the centre point, is most assuredly the portion that has suffered the greatest violence of the calamity; and unless the inexplicable producing causes have been expended in the frequent and severe shocks that have to this day continued to recur, we may from our experience of the progress of the earthquake in other parts of the world, with reason, as we ought with resignation, look forward to further and more violent exhibitions of the same terrible nature.

In the notice of the earthquake by the secretary of the Asiatic Society, in his journal for August, he expressed a belief that the greatest intensity of the shock would be found to have occurred beyond the Himalaya, in the direction of Lassa; and judging from the direction from which the shock would be found to have proceeded, and its intensity in the valley of Nepal, such was the probability, though other has turned out to be fact, and that upon good authority.

The recent return of an Embassy from Nepal to the court of the celestial emperor, has furnished authentic information on this subject, which otherwise might have been long wanting; and the hole tenor of it shows that the great Himalayan range itself, and the country on *this* side of it alone was the theatre of the earthquake's presence, and that it was not even in the slightest degree felt beyond a very short distance on the Tibetan side of those huge mountains.

The embassy was at Lassa, on the 26th of August, when and where the shock was not experienced. At **Digarchi**, in the following month, it first received accounts of its occurrence from Nepal; to the inhabitants of that place the circumstance was known only from reports brought from this side of the

mountains; along the road **from Digarchi**, the answer to all inquiries was the same. "No earthquake on the 26th August," and not until its arrival **at Tingri** was it found that the shock had been felt. Tingri is a small Chinese post, immediately beyond the great Himalaya, and the first stage on the tableland (as it is called) of Tibet, going from hence to Lassa, (by the Kuti or eastern pass from the Valley of Nepal). From **Tingri to Kirung**, a distance of 8 or 10 marches, the route is nearly due west, running along; and through the northern side of the Himalaya, and throughout this tract, though but thinly inhabited, authentic reports of the occurrence of the shock were received. **By Kirung** (the eastern pass from the valley into Bhote), the mission penetrated the great range, and at each stage (four in number through the pass) intelligence of the occurrence was communicated by the few individuals who inhabit that wild and sterile region. But such information was not required, as its effects were sufficiently manifest: in the village of **Kirung** itself, supposed to contain 400 houses 60 were fairly demolished, and many more seriously injured: two men had been killed under the ruins of their houses, and about a dozen injured.

From the **exit of the pass to Kathmandu** there are no towns along the route, and scarcely any villages; but at many places, insulated (?isolated) houses of the mountaineers had been thrown down, and the precipitous banks of hills and mountains had been hurled into the subjacent valleys.

This shows the extent of damage done towards the north, and enables us to fix the line of **Tingri** (Lat. 28) as the northern limit, of the earthquakes presence, and reports would show that of **Jabalpur** and **Calcutta** to have been the southern one. **Rangpur** defines the east (footnote from editor-Mr. Walters informs me that it was also felt at **Chittagong**), and **Delhi** the west.

Northeast from Kathmandu as far as **Dulka** and **Kuti**, the violence would seem to have been greater than in the valley. West from Kathmandu it diminished at every step. At **Gorkha**, only two houses were destroyed; at **Palpa**, none; and at **Doti**, on the borders of Kumaon, the shock was felt, but by no means severely. It will strike everyone as remarkable, that while here the shock was more violent than elsewhere, its effects should not have been felt equally at as great a distance from hence to the north as to the south.

I subjoin an accurate register of the shocks which have occurred up to this date, given me by Captain Robinson. Many of them have been severe, and throughout the whole course of these visitations, there have been two distinct varieties observed in the characters of the shocks, all those at the commencement were undulatory or swinging kind; the others wanted this swell, and were a violent up and down shaking with little vertical motion. The first may be called horizontal, the latter the vertical, variety. The former alone have been destructive to property, while the latter, from the greater noise by which they are accompanied, and the more rapid oscillations of the ground, are perhaps more terrifying.

Register of earthquakes at Kathmandu, from the 26th August to 26th November 1833 inclusive.

Aug 26	17:55, 22:50, 22:58 duration 3 minutes, nine others all horizontal
Aug 27	04:53, 05:20, 05:26 horizontal
Aug 28	07:25, 16:55 horizontal
Aug 30	09:00 and 3 other shocks
Aug 31	2 slight during the night
Sept 1-11	10 slight shocks
Oct 4 07:30	smart vertical shock 1 m duration, felt at Gorackpur and Allahabad
Oct 18	13:15 severe vertical, duration 1 min, felt slightly at Allahabad
Oct 26	10:37 slight
Nov 8	01:35 slight
Nov 16	24:00 slight
Nov 26	23:45 severe vertical 1 m duration (occurring at the full moon)