Comment on "Interpreting the style of faulting and paleoseismicity associated with the 1897 Shillong, northeast India, earthquake" by C. P. Rajendran et al.

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[1] *Rajendran et al.* [2004] dispute the location of the inferred 110-km-long south-dipping Oldham fault that was responsible for the 1897 M_w = 8.1 earthquake rupture beneath the Shillong Plateau [*Bilham and England*, 2001]. In doing so they take the unusual step of citing, and then ignoring, the precise triangulation data with which its location and slip were quantified.

[2] Specifically, they overlook data from the Assam Valley triangulation series [*Strahan*, 1891] that passes close to the region of the hypothetical fault that they invoke to replace the Oldham fault (Figure 1). The triangulation line was first measured in the mid-19th century and remeasured in 1936/1937 [*Wilson*, 1939]. Wilson's vectors show southward surface displacements of up to 3.3 m that are inconsistent with south dipping, reverse slip near the Brahmaputra river at any depth (Figure 1). *Nagar et al.* [1992] and *Bilham and England* [2001] present strain analyses of these data that constrain the rupture parameters of the 1897 earthquake to ±5 km south of 26°N.

[3] *Rajendran et al.* [2004] assert erroneously that MSK intensity VIII observations correspond partly to the region of coseismic level changes reported by *Oldham* [1899] in the Brahmaputra Valley. Inspection of Figure 2 of *Ambraseys and Bilham* [2003] reveals that intensity VIII is entirely confined to the plateau, with a maximum IX above the inferred Oldham fault, and with a smooth decay in intensity northward and eastward across the region of the imaginary fault claimed by *Rajendran et al.* [2004].

[4] As in the Bhuj 2001 earthquake, faulting in the Shillong 1897 earthquake terminated ~9 km below the surface resulting in a long-wavelength (>30 km) surface deformation field. The geological expression of subsurface slip was in each case surface flexure and secondary faulting. In the case of the 1897 earthquake, however, the Chedrang normal fault was driven east-up with slip of up to 10 m. *Bilham and England* [2001] calculated that maximum slip, and its southward decay corresponds well with the slip distribution of a 9 km wide vertical fault, freely slipping in response to subsurface slip on the Oldham fault at 9 km depth but only if the NW tip of the Oldham fault lies below the northern tip of the Chedrang fault. This not only confirms the sense of slip on the Oldham fault but provides independent of confirmation of its depth and location.

[5] Shuttle Radar Topography Mission (SRTM) imagery shows that the Brahmaputra river lies at the base of a gentle alluvial fan uninterrupted by morphological features indicative of recent surface faulting The vertical deformation field inferred to have accompanied slip during the 1897 earthquake is calculated to have caused the southern Brahmaputra Valley to tilt locally ~10 μrad southward with ~1 m subsidence near the plateau and ~25 cm subsidence near the river. Thus *Oldham*'s [1899] observations of river level changes exceeding 1 m, which *Rajendran et al.* [2004] interpret as surface faulting near the Brahmaputra, presumably record the hydrodynamics of downstream sedimentation, liquefaction, and bank collapse (see discussion by *Ambraseys and Bilham* [2003]).

[6] *Rajendran et al.* [2004, paragraph 31] claim that gravity and seismic data are consistent with the presence of a fault that projects to the surface near ~26.25°. These data do nothing of the sort as can be seen from the data that they reproduce in support of this statement. The gravity data are shown without uncertainties or interpretive model. The seismic data consist of poorly located hypocenters with no hint of preferred fault location, dip, or strike.

[7] Throughout their article, and specifically in paragraph 33, *Rajendran et al.* [2004] discuss a hundred years of tectonic interpretations of the 1897 earthquake with equal weight. Survey of India geodetic data provide numerical constraints for the mechanism and location of the 1897 earthquake that render obsolete all earlier speculation based on incomplete or qualitative descriptions of subsidence, uplift, or intensity data. The rupture length of the 1897 earthquake was 110 ± 5 km, its shallowest depth was 9 ± 1 km, its strike was N110 ± 5°E, and its slip was 18 ± 7 m, with a NW corner near 26°, 91.6°E. *Rajendran et al.* [2004] provide no reanalysis of the geodetic data that question these parameters.

[8] In conclusion, *Rajendran et al.* [2004] propose a fault near the Brahmaputra river, activity on which during the period 1859–1939 is refuted by geodetic data and whose location is not required by currently available geomorphological, seismic, or gravity data.

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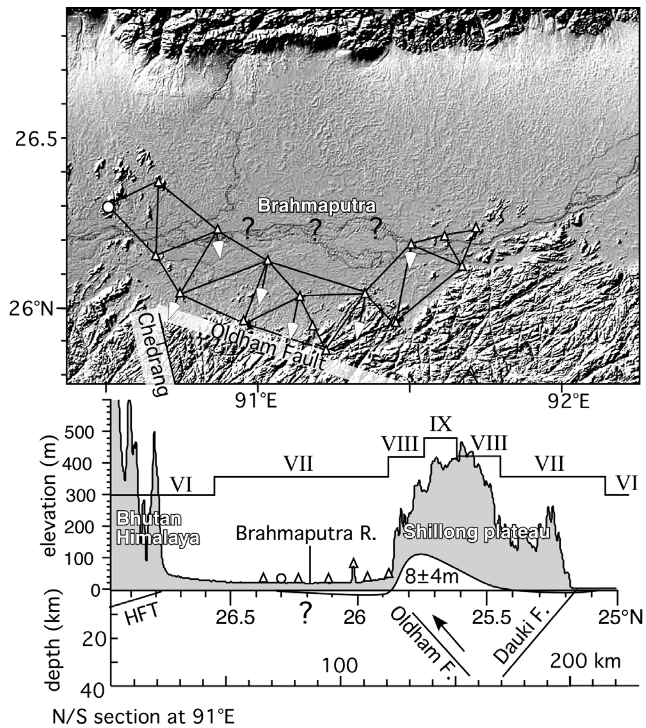

Figure 1. SRTM image of the Brahmaputra river north of the Shillong plateau illuminated from the north. Points of the Assam triangulation series (triangles) first measured in 1859 [*Strahan*, 1891] were displaced by up to 3.3 m relative to the circled point in the 1897 earthquake [*Wilson*, 1939]. There is no evidence for active faulting near the Brahmaputra river where *Rajendran et al.* [2004] favor 1897 rupture (question marks). In contrast, the observed and synthetic vertical deformation field calculated here from the solution presented by *Bilham and England* [2001] is consistent with morphology, maximum observed MSK intensities [*Ambraseys and Bilham*, 2003], and the observed location of maximum slip (~10 m) and length (~35 km) of coseismic faulting on the Chedrang normal fault mapped by *Oldham* [1899].

References

Ambraseys, N., and R. Bilham (2003), MSK isoseismal intensities evaluated for the 1897 Great Assam earthquake, *Bull. Seismol. Soc. Am.*, *93*(2), 655–673.

Bilham, R., and P. England (2001), Plateau pop-up during the great 1897 Assam earthquake, *Nature*, *410*, 806–809.

Nagar, V. K., A. N. Singh, and A. Prakesh (1992), Strain pattern in N.E. India inferred from geodetic triangulation data, *Mem. Geol. Soc. India*, *23*, 265–273.

Oldham, R. D. (1899), Report of the great earthquake of 12th June 1897, *Mem. Geol. Surv. India*, 379 pp. (Reprinted by Geol. Surv. of India, Calcutta, 1981.)

Rajendran, C. P., K. Rajendran, B. P. Duarah, S. Baruah, and A. Earnest (2004), Interpreting the style of faulting and paleoseismicity associated with the 1897 Shillong, northeast India, earthquake: Implications for regional tectonism, *Tectonics*, *23*, TC4009, doi:10.1029/2003TC001605.

Strahan, G. (1891), Great trigonometrical survey of India, Assam Valley triangulation, *Synopt. 32*, Surv. of India, Calcutta.

Wilson, C. A. K. (1939), Triangulation of the Assam Valley Series, *Geod. Rep. 1938*, pp. 10–22, Surv. of India, Dehra Dun.

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