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Contemporary tectonics of the Himalayan frontal fault system—folds, blind thrusts and the 1905 Kangra earthquake: Reply

R. S. YEATS and R. J. LILLIE

Department of Geosciences, Oregon State University, Corvallis, OR 97331-5506, U.S.A.

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OUR paper received two responses, one from Professor Chander, to which we respond here, and one from the Earth itself in the form of the largest Himalayan thrust earthquake since 1950 which occurred on 19 October 1991. Preliminary analysis of data from a few stations reveals that this earthquake probably occurred at shallow depths on a thrust dipping gently north; magnitude was about 7 (S. Jaumé, Lamont-Doherty Geological Observatory personal communication 1991). This earthquake confirmed the suggestion of Chander (1988), Yeats & Lillie (1991) and Gahalaut & Chander (1992), among others, that major earthquakes do occur on the décollement thrust between the Himalaya and the Indian shield.

We are in basic agreement with Professor Chander and his colleagues that the basal décollement constitutes a major earthquake hazard in the Himalaya, and this décollement reaches the surface south of the Main Boundary fault. The main concerns raised in Chander's Discussion are that in our review of the 1905 Kangra earthquake, we focused our attention on the Mohand anticline south of Dehra Dun, implying that the earthquake occurred close to the Himalayan front. Modeling by Chander (1988) and Gahalaut & Chander (1992) suggests that the subsurface rupture zone extends farther north beneath the Lesser Himalaya as far as the décollement fault beneath the Main Central thrust.

We agree with Chander that the main rupture zone of the 1905 Kangra earthquake, like the hypocenter of the 1991 earthquake, lies beneath the Lesser Himalaya. Indeed, the isoseismals of the 1905 earthquake near Kangra and Dharmsala (Yeats & Lillie 1991, fig. 7) show the greatest shaking near the Main Boundary fault about 70 km northeast of the Himalayan front at Soan Dun and the Janauri anticline. However, the main geologic and geodetic evidence for the 1905 earthquake is found near the Himalayan front, where the basal décollement thrust approaches the surface. The situation is similar to that for the 1971 San Fernando, California, earthquake on a N-dipping reverse fault (Whitcomb *et al.* 1973). The mainshock was beneath the San Gabriel Mountains, 12–15 km north of the surface fault rupture and the zone of coseismic geodetic change (cf. Savage *et al.* 1975).

In summary, we have no disagreement with Professor Chander; we agree that the greatest shaking is likely to be in the Lesser Himalaya directly above the mainshock. The greatest potential for ground rupture, however, is the Himalayan front.

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