Geomorphology Field Training in tectonically active mountain regions

Intensive training course: brief descriptive report.
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General description:

The first day of the intensive training course was dedicated to oral presentations from experts to us. The talks included mainly the principal topic of the course, the geomorphology of tectonically active mountain regions, but also other topics, like coastal geomorphology, landslides and disasters evaluation. In this day we watched eight presentations, an activity that consumed all the day. In the last day of the field trip we suggested more practical activities and more opened discussions with the presenters and between us (young students).

The second and third days were composed by the field trip, they are detailed below. The field trip occurred in the Dehradun valley, which is a Doon Valley, a common type of valley in the South part of the Himalayas. The Dehradun valley has the lesser Himalayas in north and Siwaliks in the south as boundaries. It has two important Indian drainage systems: Yamuna in the west and Ganga and in east.

Field trip: day 1:

The second day of the intensive course was a field trip from the Dehradun city to Mussorie city. In the way to Mussorie, we stopped exactly over the MBT (Main Boundary Thrust), a very important active fault for the Himalaya mountain belt development (Figure 1). This area has some houses with *Eucalyptus melliodora* grove. Some of them are very tortuous which may indicate some slow soil movement. Probably, that area has some risk to landslides occurrence in the future.

In the Main Boundary Thrust we saw a great lithological contact between the Krol group (at this point the lithology was a black shale) and younger rocks. The beginning of the Krol group is in the left side of the yellow line of the Figure 1 (A). The Krol group has a terminal proterozoic age and it is divided into five sections: A, B, C, D and E (JIANG et al., 2002). The Infra Krol Formation and Krol Group are part of a

Neoproterozoic and Lower Cambrian succession more than 12 km thick (JIANG et al., 2002). These authors also indicate the lithological complexity of this succession, the lower half part consists of quartzite, sandstone, argillite, carbonate rocks, and minor mafic volcanic rocks, while the upper half part of the succession has diamictite, siltstone, and sandstone of glacial and glacial-marine origin.

Figure 1 – Photo over the MBT in the way to the Mussorie city (A), the yellow line indicates approximately the direction of the lineament. Detail of tortuous *Eucalyptus melliodora* in the south side of the fault.

Returning to the road, the second point was in the contact of the Krol group with the Tal formation. The Tal Formation has a Cambrian age and includes purple grey siltstone and channel sandstone, orthoquartzite of fluvio-deltaic and marine shelf facies at the top of the sequence (TEWARI and TUCKER, 2011). In the point of contact with the Krol group, we saw a nice contact between Phyllites (Krol E?) and quartzites (Tal formation) – Figure 2.

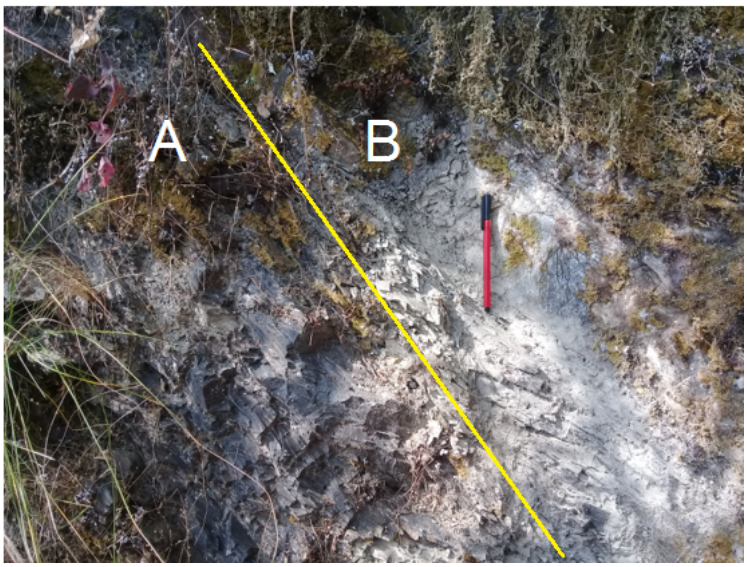

Figure 2 – Photo of the contact between the Krol group (A – Phyllite) and the Tal formation (B - Quartzite). The yellow line indicates the approximal contact.

Field trip: day 2:

The second day of field trip was eastward from Dehradun. We traveled along the central axis of the Dun, crossing some great tributaries of the Yamuna river and the Yamuna river itself (Figure 3). The Dehradun valley is between the Siwaliks range to the south and the lesser Himalyas to the north (Figure 3).

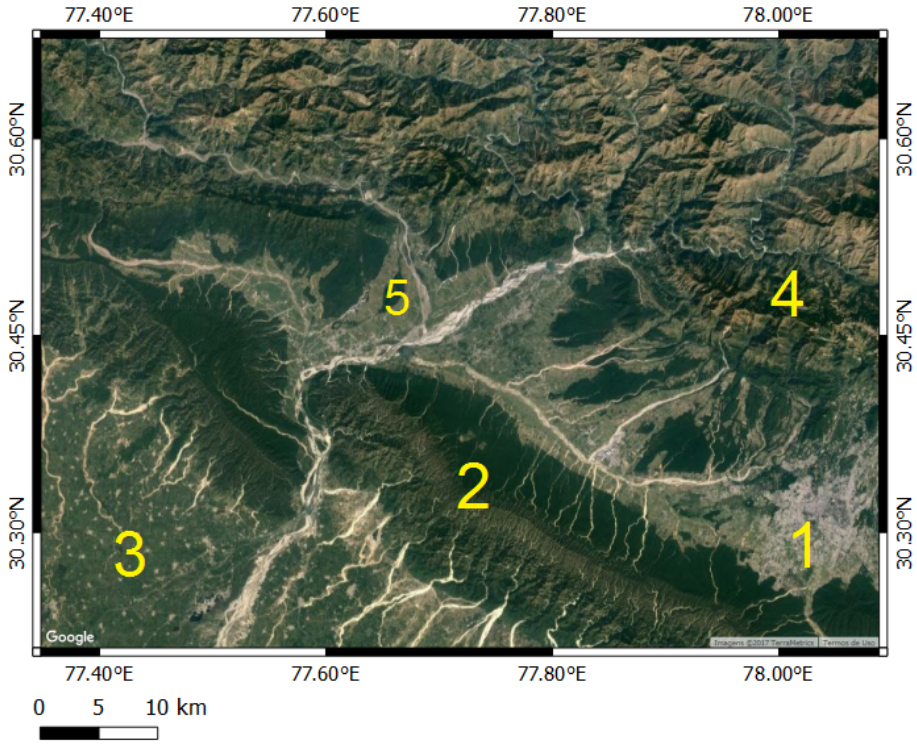

Figure 3 – Satellite image from Google earth with the main units of the region visited in the second field trip day. 1 – Dehradun; 2 – Siwaliks; 3 – Great plain; 4 – Lesser Himalayas; 5 – Yamuna river.

In the second day of field trip we stopped in several points to see some important geomorphological aspects related to the active faults and other geomorphological features. In the beginning of the day, we saw large dry braided river channels (Figure 4). For me, rivers without water are very uncommon (in Brazil, we almost don't have arid environments).

In the city of Sataun we saw the Main Boundary Thrust, one more time, and another minor fault, which crosses the first one. This minor fault crosses young terraces in the region of Sataun, which indicates the relatively recent tectonic forces. We crossed that fault in two places, the point c in the Figure 4 and in the point e of the same figure (Figure 5). Along this region, the fault is very expressive in the superficial relief, allowing its mapping from satellite images (Figure 6).

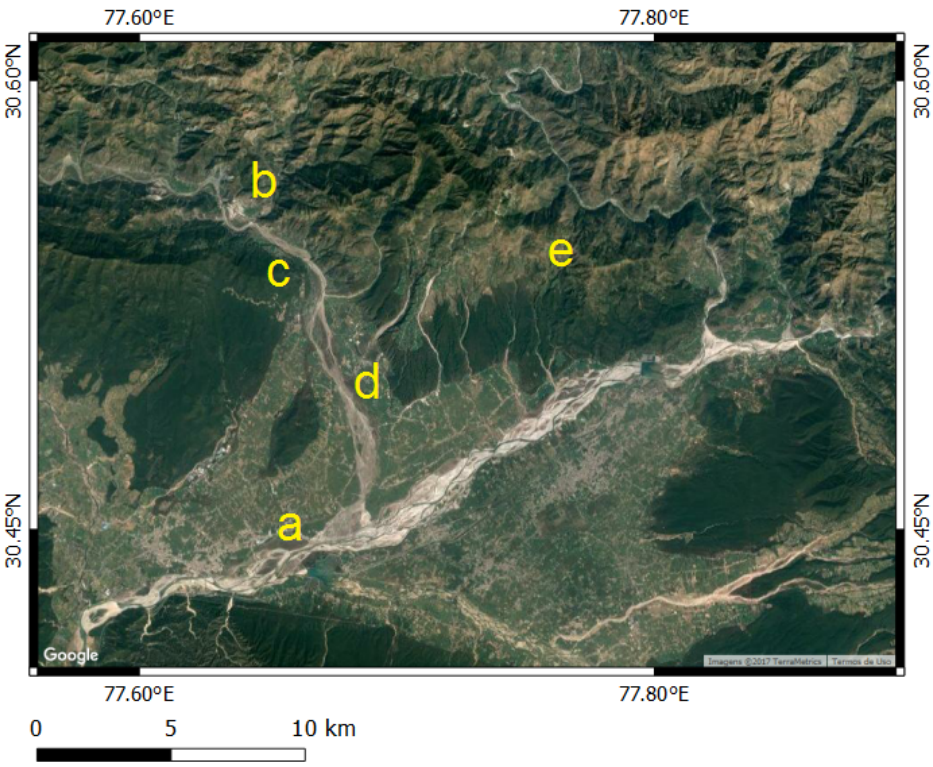

Figure 4 – More detailed satellite image from Google earth with some stop points of the second day. a – Yamuna river; b – Sataun; c – Terraces; d – Launch point: braided river; e – last point: fault.

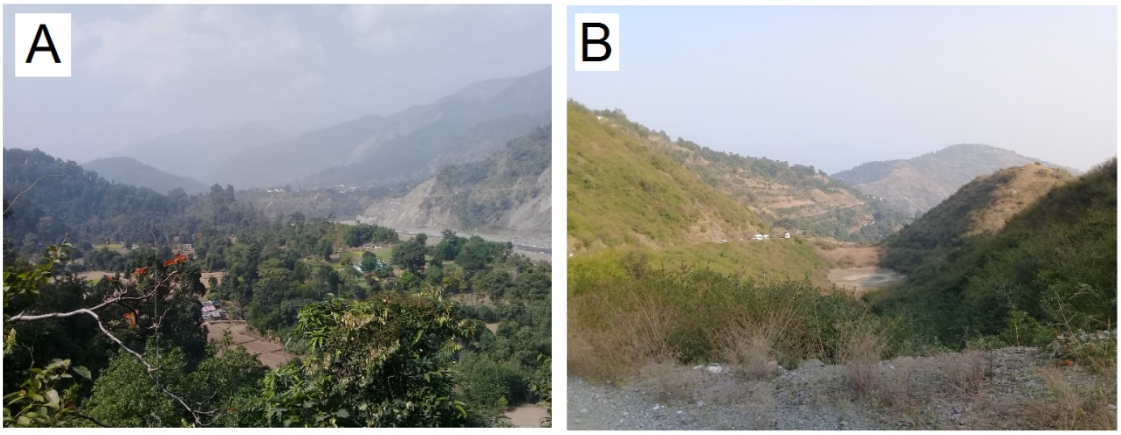

Figure 5 – Photos from the minor fault system, observed in two places. Photo taken over young terraces, the point *c* of the Figure 4 (A); Photo taken in the axis of the fault, this is the point *e* of the Figure 4.

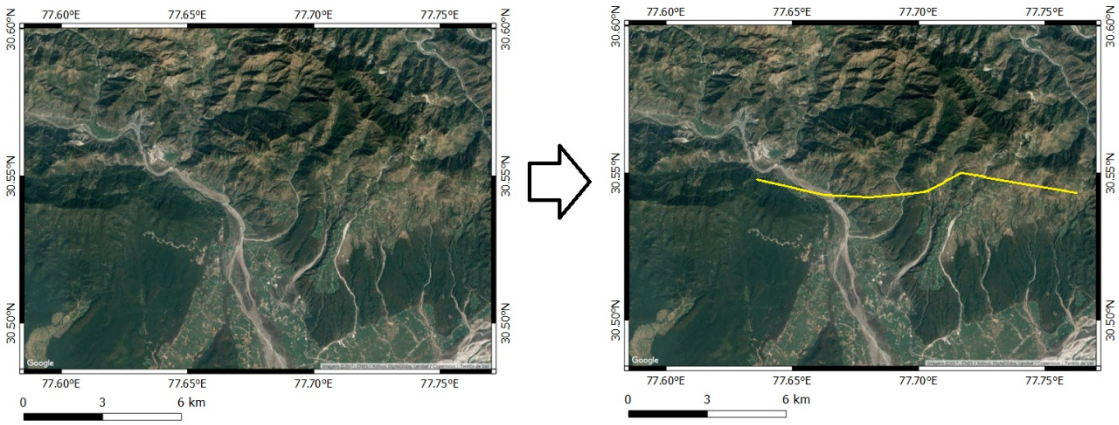

Figure 6 – Lineament mapping of the fault observed in the points c and e of the Figure 4.

References

TEWARI, V. C.; TUCKER, M. E. 2011. Ediacaran Krol carbonates of the Lesser Himalaya, India: stromatolitic facies, depositional environment and diagenesis. STROMATOLITES: Interaction of Microbes with Sediments pp. 133-156.

JIANG, G.; CHRISTIE-BLICK, N.; KAUFMAN, A.; BANERJEE, D. M.; RAI, V. 2002. Sequence stratigraphy of the neoproterozoic Infra Krol formation and Krol group, Lesser Himalaya, India. *Journal of sedimentary research*, v. 72, n. 4, p. 524–542.

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