Search for Gorkha earthquake surface rupture 4 May 2015

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No slip occurred on the Main Frontal Thrust (MFT), but initial interferograms showed a weak but persistent east-west discontinuity (Eric Fielding , personal communication, 1 May 2015) at approximately 85.73°E, 27.24°N northeast of the village of Kalpabrishykha and extending ≈25 km to the west near Raigaun. The west end of the discontinuity was visited to search for surface rupture. We identified a hairline crack and a liquefaction feature 27.2396N, 85.7258E but no thrust rupture. We evaluated EMS Intensity 6 from damage to structures in the 2 km x 2 km region near these features.

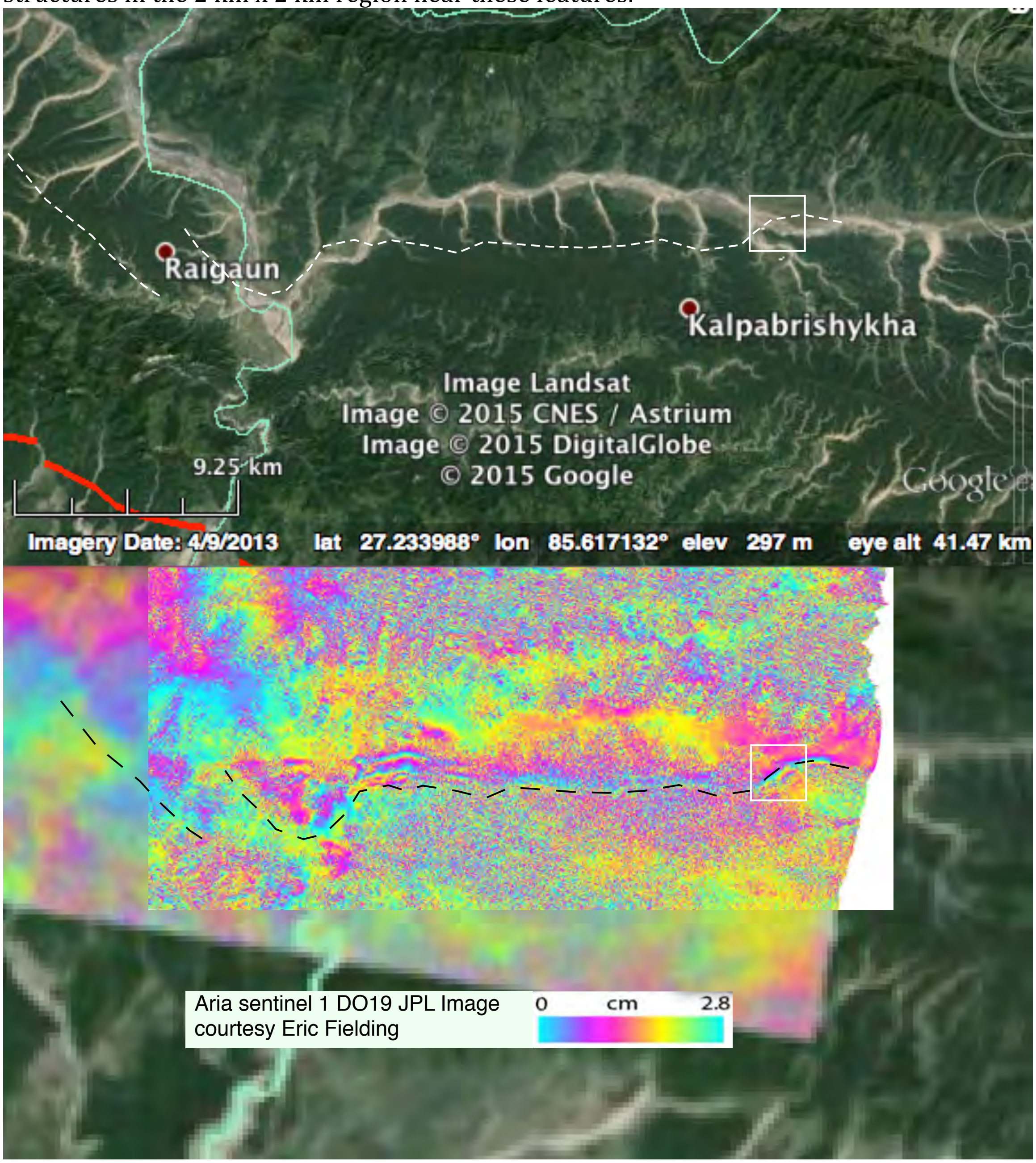


Figure 1. Image of 2-5cm dislocation in 1 May Aria Sentinel 1 scene (provided by Eric Fielding) for which we searched 4 May (white box shown in Figure 2).

Figure 2 Close up of inset region shown in Figure 1 consists of a 2-km-wide, anastomosing river channel with fields of agriculture near its edges leading to forested slopes of hummocky Siwalik hills. The approximate path of the Insar discontinuity is shown by a green dashed line. Black circle is landing spot for helicopter. Cracks identified by villagers shown as solid lines. Black squares approximate locations of 26 Megapixel images. Yellow dashed line region inspected on foot.


Figure 3 View north from the westernmost black box in Figure 2 at approximately 100 ft elevation.

The Insar discontinuity follows a forested ridge (Figure 1) but in the region inspected it crosses a north-flowing tributary to an east-to-west flowing anastomosing channel fronting hills to the north. On landing a diligent search revealed no evidence for cracks in the river bed or the dry fields. However, in response to our enquiries about cracks in the ground subsequent to the earthquake, the villagers responded eagerly by showing us first a hairline fissure approximately 800 m north of the coordinate inferred from the interferogram and then a much larger fissure that had ejected water and silt during the earthquake approximately 1 km to the SW.

The hairline fissure was east-west and about 10 m long and barely visible (ten days after the earthquake) where it had cut recent vehicle tracks in mud. It lay on eastern edge of the flood plane of the river close to the edge of a north-facing slope where it petered out amid a stiff clay covered hillside covered by bushes and trees (near the forested bluff on the right in Figure 3). No vertical or lateral offset was evident in this fissure.

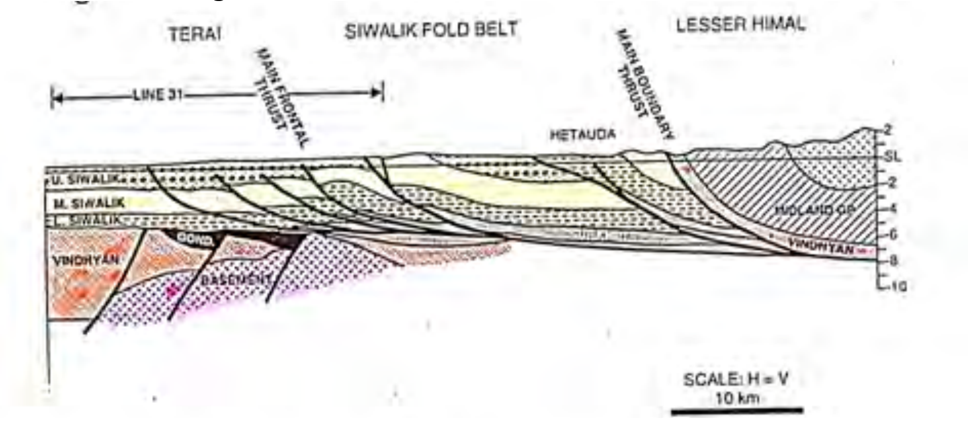
Figure 4. Hairline fissure to north of initial search area viewed looking west.

The second fissure was also east west and about 650m long and was initially reported to exceed 10 cm in width and 2 m depth. It cut through a field of maize and passed near a cylindrical, concrete-lined water well. During the earthquake (shortly after shaking commenced) both the well and the fissure expelled water and silt. After some tens of minutes this ceased and the fissure closed. The well was dry when we visited it. A thin layer of silt now covered the field downhill from the fissure, that at the time of our visit was nowhere wider than 2 cm. It is possible that the soils across the crack had been offset by 1-2 cm down to the north.

Figure 5 (left): Liquefaction crack with silt covering soil layer.

We deduced that the fissures in the river bed had resulted from shaking and liquefaction during the earthquake. An attempt to follow these fissures to east and west from the air was unsuccessful since their projection led to forested rough terrain (Figure 6), where it was impossible to land a helicopter or to view through the trees.

The remarkable knowledge by the villagers of the fissures in their land (Figure 6), suggested to us that had a rupture occurred in the region, the villagers would have noticed it. We were searching for a subtle feature (1-2 cm of thrusting) and the features we had been shown were similar in size, but indicative of opening. Assuming that the dislocation in the Insar image was real we concluded that the convergence or uplift feature visible in the image must have terminated in the subsurface. Given that it interrupts a very gentle gradient in convergence to the north (<2 cm in 10 km) the possibility that coseismic décollement rupture had reached the study region could be refuted. We concluded during the site inspection that local liquefaction settlement may have contributed significantly to the observed fringe dislocation.



However, the westward continuation of the dislocation tens of km to the west through a forested drainage divide (Fig. 1) would require regional convergence and/or uplift that could not result from liquefaction. The <5 km width of the local fringe perturbation north of the maximum gradient suggests that local southward slip was confined to the uppermost ≈2 km (Angster et al., 2015, Fielding et al., 2015). Slip may have been induced locally on one of two splays between the MFT and MBT shown by Bashyal et al., (1998; section shown above). Husson, et al., (2004) term one of these faults the Main Dun Thrust. Long term slip of the fault splay that slipped appears to be responsible for back-tilting the divide visible in Figure 1 northwards, confining the prominent east-west anastomosing channel to its northern edge against the mountain front visible in Figure 3. The back-tilting process is similar to that which confines the Jhelum to the northern edge of the Kashmir Valley (Bilham and Bali, 2014).

Figure 6 View west from study area showing forest cover and hummocky terrain and an absence of landing sites.

Figure 7. Masonry structures (200 m south of the liquefaction fissure) showed no evidence for damage except of the loss of a few tiles near end gables (Intensity 5-6).

We next flew 2 km west (Figure 6) searching for fissures and finding no evidence within the forest cover we turned around and flew east for 20 km. In the region within 4 km of the fissure search we inspected building damage and found that a few houses had lost their tiled roofs but most, like those near the fissure had no visible damage (Figures 7-11). Of the 50 dwellings we inspected, only one family had erected a tent suggesting that the roof damage and expectation of damage to walls from aftershocks was minimal.

Figure 8 Damage to one roof (lower right) Building under construction (left)

Figure 9 Damage to roof and wooden pillar soft storey misalignment in central building.

Figure 10 No damage to masonry ground floor or wooden superstructure and roof.

Figure 11 No evident damage to lightweight soft story barn. Possible loss of end-porch roof cover lower left.

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