Table 1 *a*. Modalities of ejection of marking fluid in the Asiatic lion

Total no.	Upward only	Upward to downwards	Downwards		Horizontal
			Vertically	At an angle	
175	0	52	53	6	64

Table 1 *b*. Comparison of modalities of marking fluid ejection by several cats

Cat species	Modality of marking	Gender bias
Asiatic lion	Highly flexible, up to down, vertically down, horizontally backwards	Predominantly male activity
Tiger	Upwards	Marking frequency high in both sexes
Cheetah	Jerks up to down or vice versa	Predominantly male activity
Leopard	Upwards	–
African lion	Upwards but details not known	Predominantly male activity

Sarkar and Brahmachary[10], that of the cheetah.

In this note we report a distinctive feature of the marking behaviour of the Asiatic lion which may be compared with that of some other big cats. A lion and a lioness in an enclosure in the interpretation zone, Gir National Park, were first observed. It was noticed that like the African lion[5], marking in the Asiatic lion is a predominantly male activity. Later, a second lion was observed in the same setting and the different modalities of marking were now meticulously recorded for this animal (Table 1 *a*).

It is evident that unlike the tiger[6,7] and leopard[11], the Asiatic lion enjoys a very flexible modality of squirting marking fluid; not one was purely upwards as in the case of tigers, 52 started upwards but switched over to downwards rather like cheetah[10], 64 were horizontal, backwards spray, while 39 struck downwards (33 vertical and 6 at an angle).

The comparative study (Table 1 *b*) may be of interest for comparative ethology.

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The devastating landslide of August 1998 in Ukhimath area, Rudraprayag district, Garhwal Himalaya

It was a week of disaster from 11 to 19 August, 1998 in the Ukhimath area in Garhwal Himalaya. The landslides affecting 20 km^2 area occurred in two phases along the lower catchments of the Madhmaheswar and Kaliganga rivers. The study area lies between 79°03' to 79°09'E longitudes and 30°35' to 30°35'N latitudes, in the Great Himalaya. The northern extent of the landslides is seen from the confluence with the Mandakini River up to Lenkh in the Madhmaheswar valley, and up to Khunnu (Kotma) in Kaliganga valley.

The landslides occurred in the vulnerable Main Central Thrust zone (Figure 1) characterized by continued minor and periodic major seismic events, highly crushed and pulverized rocks, fans and cones of loose debris on steep slopes, seepages in linear belts and deforestation together with increased road-building activity. The landslides were triggered during heavy rains, but the controlling factors were geological structures, relief, surface cover of loose debris and unscientific road construction[1]. The first event occurred on 11/12 August 1998 throughout the area. On 18/19 August 1998 following high-intensity incessant rainfall in Madhmaheswar valley, villages Bhenti (on the left bank) and Pundar (on the right bank) went down in ruin and the flow of the Madhmaheswar river was blocked for about 12 h due to the forming of a debris dam. Later the dam breached, leaving behind a 1.2 km long, 50–70 m wide, and 25–30 m deep lake in the valley.

The losses assessed by the local administration are: 101 human lives, 422 heads of cattle, 820 houses and 411.55 ha of agricultural land, the aggregate amounting to Rs 41 million. In all 29 villages, 9752 people were affected. The roads were maximally damaged, mainly along Ukhimath–Mansuna–Jugasu, Guptkashi–Kalimath–Kotma and Guptkashi–Kedarnath segments. The suspension bridge at Jugasu

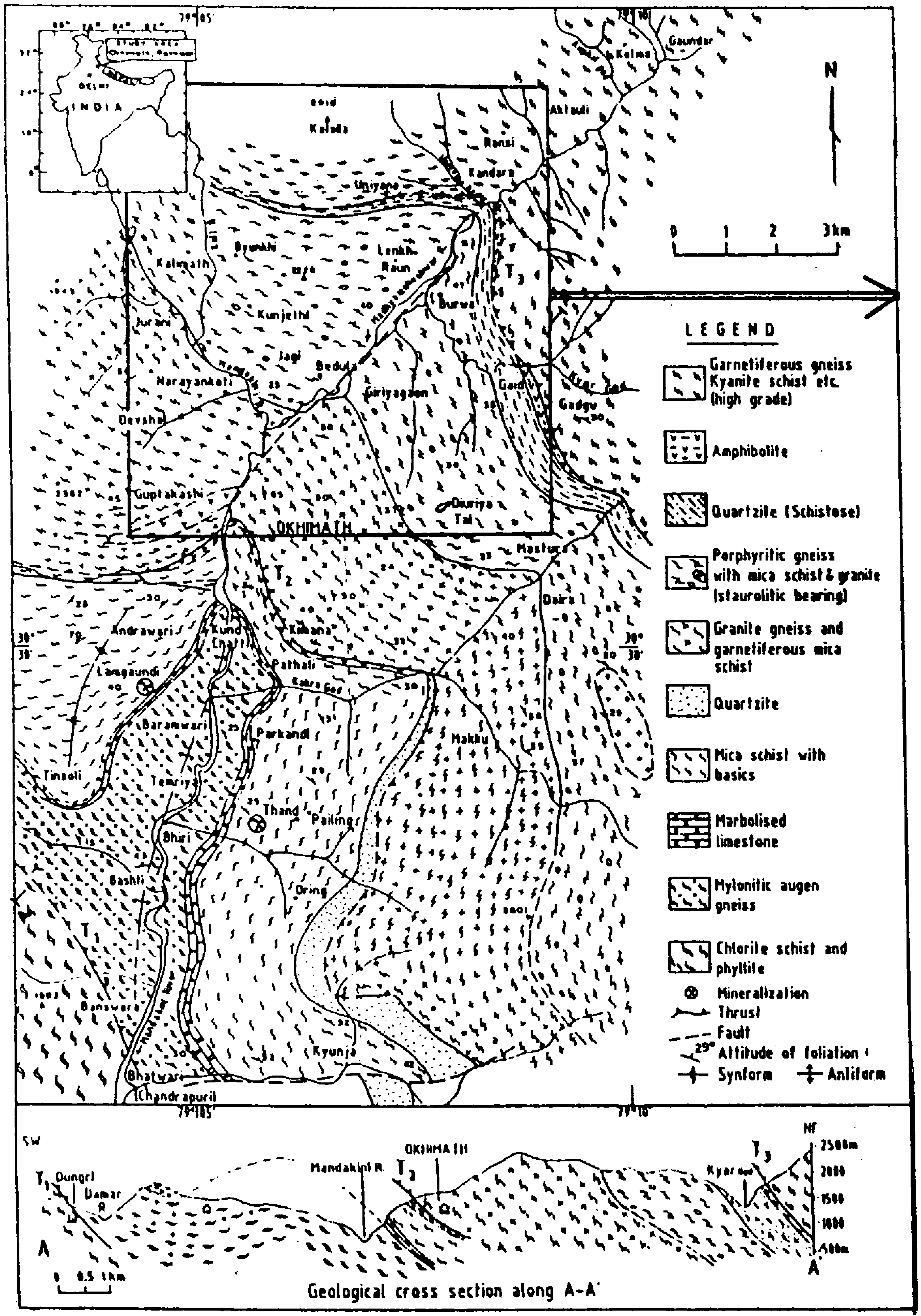

Figure 1 *a*. Location and geological map of the Ukhimath area. Outlined area is the site of tragedy. .

on the Madhmaheswar river was washed away.

The Kalsila ridge in Madmaheswar and Kaliganga valleys at the altitudes of 1800–2000 m was ravaged due to rotational slips and debris flow, while translational slides and wedge failure occurred on the right bank of the Madhmahewar river (Figure 2 *a*). Along the Guptkashi–Kedarnath road, lunar cracks developed at many places near Guptkashi, causing 2–3 m subsidence. In the Madhmaheswar valley, the Ukhimath–Mansuna road sank 10–40 cm and developed 10–150 m long lunar cracks.

Geological setting

The landslide occurred in the Main Central Thrust (MCT) zone (Figure 1 *a*), which consists of schists and gneisses interbanded with quartzites and metabasic rocks[2] and described variously as Central Crystalline Zone[3], Munsiari

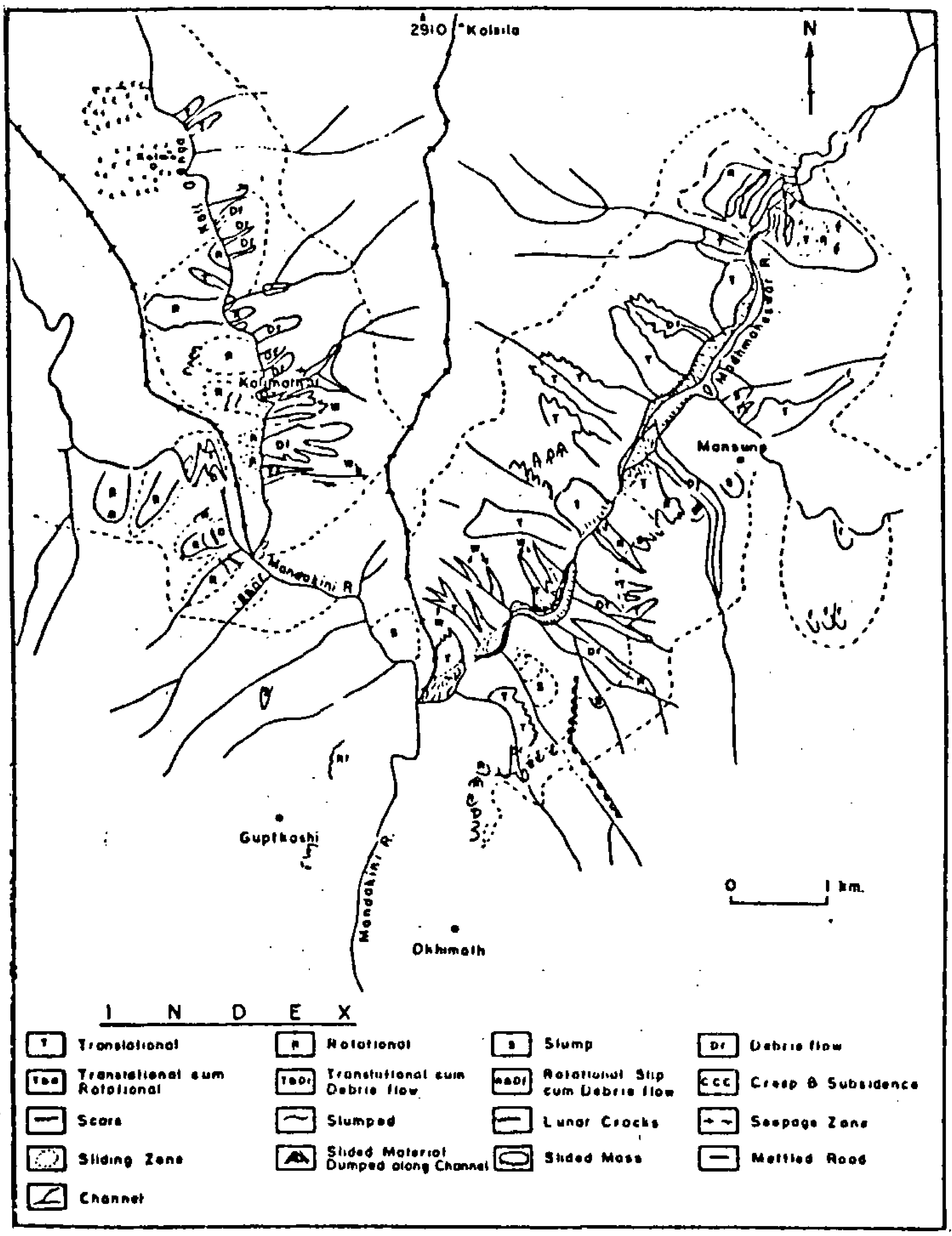

Figure 1 *b*. Distribution of different landslides in the Ukhimath area.

:mation and Vaikrita Group[4], and ntral Crystallines[5]. The NW-SE king rocks are highly fractured and ;ared and dip 40–70° towards north to ·theast. The rocks have a thin (1– m) cover of regolith on slopes.

ass movements

e Vaikrita Thrust of the MCT zone 1 the NNE–SSW trending strike slip lt along the Madhmaheswar valley the ones responsible for the present ›pening. Opening of fractures and lures of either of the four sets of nts, i.e. (1) E–W with 70–76° dip due ıth, (2) NW–SE with 20–25° dip due ;, (3) NE–SW with 70–80° dip due W, 1 (4) NNW–SSE with 60–70° dip due W, caused the slope-failures leading to extensive mass movements. The interaction of two or more joint planes is marked with a wedge failure and translational slide. Slopes having small agricultural terraces (Figure 2 *b*) with thin soil cover and characterized by two or more sets of joints were ravaged by translational slides. Debris flows were common along high-gradient tributary streams, the valleys of which are confined. In the case of most of debris-flows, minor rotational slips and translational slips blocked the channels and created minor blockades which later gave way, leading to draining out of the pools. It was evident that the zone which is mainly under human occupation on steep slopes was severely affected.

The rotational slips, generally triggered by high porewater pressure, are developed along deeper slip surfaces where thickness of the Quaternary regolith is 5–50 m or more[6]. At Bhenti (Figure 3 *a*), north of Burwa, the depth of slide at its thickest and distal portion is 80–90 m, the average depth at basal rotation plane being 50–60 m. The slide moved at least 1100–1200 m along the left valley slope and rode up 150–200 m on the right bank slope of the river, covering the lower slope of Raun-Lenkh where Pundar (now buried under rubble) was situated[7]. The length and width of unconsolidated slid mass across the river is 160–200 m wide and 200 m long. The debris mass totally blocked the flow of the Madhmaheswar river from 2 a.m. to 2 p.m. on 19 August, thus creating 1000–1250 m long, 50–70 m wide and 25–30 m deep lake in the valley. This blockade was subsequently breached.

At Bhenti, the slide is about 660–680 m high and 550–600 m wide, covering a width of 700–800 m and the length of 665–700 m.

Causes of landslides

A combination of several factors is responsible for the Ukhimath landslides like tectonically disturbed and fractured lithology of the MCT zone, past and recent seismic events, loose regolith, Quaternary cover on steep slope, prominent seepage zone, increased anthropogenic activity and faulty landuse practices. In addition, ill-planned road construction and rapid infrastructural developmental activities added to the problem. Though all these factors directly or indirectly have a bearing on the landslide activity in the region, action of water during torrential rain was the main triggering factor.

The fractured and highly jointed nature of the bed rock (granite gneiss) in the MCT zone – especially the steeply-dipping southwesterly joints – and uncontrolled blasting for a new road are mainly responsible for rockfall and wedge-failure at Banswara (Figure 3 *b*), south of Ukhimath. At Bhenti, uncontrolled blasting for construction of the Burwa–Jugasu–Raunlenkh road with its hair-pin bend near Burwa in the Vaikrita Thrust zone greatly weakened the stability of the hill slope. The infiltration of water from two seepage zones

Figure 2. *a*, Translational slides along steep slopes in the lower reaches of the Kalsila Ridge; *b*, Massive debris flow which damaged agricultural fields and houses along a small tributary at Phapanj near Ukhimath.

Figure 3 *a*. Panoramic view of the devastating Bhenti landslide near Burwa.

Figure 3 *b*. Rockfall and wedge failure due to deep weathering and opening up of joints at Banswara, south of Ukhimath.

increased the porewater pressure during heavy rainfall and reduced the shear strength of material along deeper slip surface. The cumulative effect of all these resulted in the massive deep rotational-cum-translational slide. Uncontrolled blasting in Mansuna–Burwa, Banswara–Kyunja and Kalimath–Kabiltha–Kotma section helped in opening and widening of joints and factures in the sheared rock of the MCT zone.

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