The Sept. 1988 Large Landslide in the Vicinity of MCT, Darbang, Nepal

ネパール主中央衝上断層近傍ダルバンにおける1988年9月の巨大崩壊

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1 Introduction

The Himalayas have been subjected to intensive orogenic movements since Miocene Period, and it is believed that uplifting of the mountain belt is still underway (Kizaki, 1988). Rapid uplifting along the main axes of Himalayas, coupled with intensive downward cutting swift current of rivers makes the slopes more and more unstable. Rocks have been extremely mylonitized and cataclastized along the major tectonic boundaries. Almost 80% of annual precipitation (ca. 1000–3000mm) is concentrated during the rainy season (mid June to mid September). Accordingly there are many large scale landslides and debris avalanches together with numerous small ones occurring in various parts of Nepal Himalayas.

Slightly more than half the population of Nepal reside in the mountain region (ca. 500–4000m a.s.l.), where frequent slope failures deteriorate the living and productive conditions of the people.

The present study describes a large scale landslide which occurred at Darbang near the Main Central Thrust (MCT), central Nepal in 1988, which killed more than 100 village people (Photo 1). The writers visited the site in October 1988, about a month after the tragedy, and in March 1989. They made geologic and geomorphologic surveys around the landslide site and hearings from village people at each visit. They also made an interpretation of aerophoto taken in 1954 to know the former topography around Darbang before this landslide occurred. Based on those researches, it considered a possible mechanism of the landslide.

2 Topographic and Geologic Overview of Nepal Himalayas

Nepal Himalayas are classified topographically into 4 east-west zones, namely Terai (less than 300m), Outer Himalaya (500–1500m), Lower Himalaya (2000–4000m) and Great Himalaya (more than 4000m) from the south to the north, which roughly correspond to the geological configuration (Figs. 1 and 2). Those 4 zones are bounded by the Himalaya Frontal Fault (HFF), the Main Boundary Fault (MBF) and the Main Central Thrust (MCT) respectively. The Terai is a northern edge of Ganges Plain. It comprises composites of fluvial fans of various ages in the late Quaternary period and various scales. The outer Himalaya is a molasse zone of the Himalaya Orogeny, and consists of various fluviolacustrine strata of Miocene to Pliocene in age. The Lower Himalaya consists mostly of metamorphic rocks of various ages from pre-Cambrian to Palaeogene, and is featured by nappes and klippen with lower grade metasediments being overlaid by higher grade crystalline rocks. The Higher Himalaya is composed with gneisses, granites and Tethys sediments, and featured by huge recumbent folds (Arita et al., 1982).

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Photo 1 A panoramic view of the landslide from the left bank of Myagdhi Khora
Scale; Relative height of collapsed scarp : 650m. Max width of debris : 500m

Fig. 1 Geological map of Nepal and location of study site

3 Darban Landslide in the Vicinity of the MCT

Darban is located about 200km west-northwest of Kathmandu, the capital of Nepal. Being one of the district town of the Dhaulagiri Zone, Darbang has several tens of shops, which comprise 'the Darbang bazaar', a district office, two banks, a high school and scattered village houses around the bazaar. The layout before the landslide had the bazaar and all the public buildings on the left bank of Myagdhi Kohla, a tributary of the Kali Gandaki River, and 15 houses across the river, on the right bank (Fig. 2).

The landslide occurred at about 11 pm on the midnight of Sept. 20, 1988 along the north facing slope of the SW-NE extending ridge (Fig. 3 and Photo 1). The debris immediately buried all the houses on the right bank of the river situated just below the slope (Photo 2), and a part of debris flowed across the Myaghi Khola burying two more houses on the left bank (Photo 3). A death toll totaled 109. The scarp shows that the height of landslide's

crown and foot is about 1750m and 1000m a.s.l. respectively, and it's width is about 500m.

Altogether about 5 million m³ of debris was assumed to have been produced by the slope failure, which ran down as far as 1500m from the crest mainly northeasterly direction (Fig. 3). The debris dammed up the Myagdi Khola for about 3 hours, but the dam was scraped gradually giving no actual flood damage downstream. The debris consists of angular breccia from several to some tens of centimeters in diameter with sandy matrix (Photo 4). A huge block, several meters in diameter, is seen in the middle of debris (Photo 1). A lot of parallel running cracks, similar to those of glaciers, can be identified on the surface of debris, mostly perpendicular to the direction of the debris flow (Photo 1).

Villagers said that the right bank of the river immediately below the collapsed slope, where the debris did not reach the river itself, extended northward and the river bed was

1: Topographic Zone 2: Geological Zone

Fig. 2 Schematic north to south profile of Nepal and its topographic classification (modified Kizaki (1988))

uplifted creating a bar and choking the river (Loc. 1 in Fig. 3). As a result water level up the bar rose by about 2m. It was confirmed by aerial photographs taken in 1954. The foot of some trees up the bar are submerged below river water (Photo 5).

Although the landslide occurred close to the end of monsoon, rain did not fall for three days just before the landslide. No perceptible earthquake was observed at that time, although an earthquake of magnitude 6.7 occurred in Eastern Nepal about a month before the present event. This earthquake's epicenter is more than 500 km away

Fig. 3 Geomorphological map of the landslide which occurred in Sept. 1988
Broken line indicates a presumed fault.

Photo 2 A whole view of debris from the ridge crest neighboring to the collapsed scarp

Photo 3 Buried houses by debris which reached onto the left bank of the river

Photo 4 Crushed detritus

from the present site.

The Darbang bazaar used to be on the right bank of the Myagdhi Khola but it was buried by an old landslide that occurred at exactly the same place as the present one 62 years ago, which killed more than 500 people. Since then the bazaar was moved across the river to the present location. Aero-photographs taken in 1954 show that the crown of the old landslide was about 300m below the present one, and the scale is presumed to be 1/3 to 1/2 of the present one (Fig. 3).

4 Geology around the landslide

The present site is located on the northern side of the Lower Himalayas. Rocks occurring around the landslide are metasedimentary rock. They are called Midland metasediments Group and are grouped into Baglung zone by Arita et al. (1982). They are black to green slates with subordinate amounts of carbonaceous rocks. Quartzite of about several tens of meters thickness was observed in the middle of the slope (Fig. 4). The metamorphic grade of those rocks correspond to the green schistfacies with mineral assemblage of chlorite-sericite. Biotite appears on some of those rocks near the top of the ridge with mineral assemblage of biotite-(chlorite)-sericite. This implies that the MCT may be situated right above those strata, since in pelitic rocks of the Midland Super Group, metamorphic grade increases abruptly immediately below the MCT from chlorite-(garnet)-sericite to biotite-sericite and to biotite-garnet-sericite (Maruo and Kizaki, 1983).

The structure of the rocks change across the crown of the scarp. Rocks to the south of the crown

show 10-20° north dipping foliations, while the structure of the rocks to the north of the crown show strikes of N70-80°W and dipping to the south (Fig. 4). Considering this abrupt change in structure across the crown, together with the fact that rocks exposed around the

crown are highly brecciated (Loc. 2 in Fig. 3), a fault which runs NW-SE direction can be presumed (Figs. 3 and 4).

5 A possible Mechanism of the Landslide

While the landslide of 62 years ago took place mainly before the quartzite layer in the middle of the slope, the present collapse occurred mostly above the layer. The widening of the scarp immediately above the quartzite layer (Photo 1 and Loc. 3 in Fig. 3), putting more pressure on the quartzite, which is usually more sustainable than pelitic rock, may account for this shift in the location of the landslide. That some parts of the quartzite layer which had constrained upward expansion of collapse, failed due to sliding of a mass below the quartzite, which can be inferred from the northward drift of the right bank, can be postulated. The failure in the quartzite resulted, consequently, in much wider failure in the relatively loose material that was supported by the quartzite layer. Thus, it can be concluded that sliding of a mass below the quartzite layer, whose sliding plane might have extended somewhere near the river bed, led to successively upward failure. The progressive development of the Darbang landslide is schematically depicted in Figure 4.

Photo 5 A bar choking the river floor, which made water level of the river emerged and trees behind the bar submerged.

Fig. 4 Geologic and Geomorphic profile of the landslide. Arrows show directions of landslides.

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