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Distribution and features of landslides induced by the 2008 Wengchuan Earthquake, Sichuan, China

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2008 Sichuan earthquake with a magnitude of Mw 7.9 induced numerous mass movements around the fault surface ruptures of which maximum separations we observed were 3.6 m vertical and 1.5 m horizontal (right lateral). The affected area was mountainous areas with elevations from 1000 m to 4500 m on the west of the Sichuan Basin. The NE-trending Longmenshan fault zone runs along the boundary between the mountains on the west and the Sichuan basin (He and Tsukuda, 2003), of which Yinghsiuwan-Beichuan fault was the main fault that generated the 2008 earthquake (Xu, 2008). The basement rocks of the mountainous areas range from Precambrian to Cretaceous in age. They are basaltic rocks, granite, phyllite, dolostone, limestone, alternating beds of sandstone and shale, etc.

There were several types of landslides ranging from small, shallow rockslide, rockfall, debris slide, deep rockslide, and debris flows. Shallow rockslide, rock fall, and debris slide were most common and occurred on convex slopes or ridge tops. When we approached the epicentral area, first appearing landslides were of this type and the most conspicuous was a failure of isolated ridge-tops, where earthquake shaking would be amplified. As for rock types, slopes of granitic rocks, hornfels, and carbonate rocks failed in wide areas to the most. They are generally hard and their fragments apparently collided and repelled to each other and detached from the slopes. Alternating beds of sandstone and mudstone failed on many slopes near the fault ruptures, including Yinghsiuwan near the epicenter. Many rockfalls occurred on cliffs, which had taluses on their feet. The fallen rocks tumbled down and mostly stopped within the talus surfaces, which is quite reasonable because taluses generally develop by this kind of processes.

Many rockslides occurred on slopes of carbonate rocks, in which dolostone or dolomitic limestone prevails. Deep-seated rockslide occurred on outfacing slopes and shallow rockslide and rockfall occurred on infacing slopes. Infacing slopes generally are steeper than outfacing slopes and hence surface rocks on infacing slopes tend to be loosened by gravity. Detachment surfaces of carbonate rocks are generally not smooth surfaces but are rough surfaces with dimple-like depressions, which are made by dissolution of these rocks. This feature is one of the most important causes to induce landslide in carbonate rocks.

Many gravitational deformations were observed on phyllite slopes. Landslides on the west of Beichuan city is probably of weathered phyllite, which had been preceded by gravitational deformation beforehand. Taochishan landslide in Beichuan occurred on probable outfacing slope of phyllite. The Formosat II images on Google earth indicated that this landslide was also preceded by gravitational deformation, which appeared as spur-crossing depressions with upslope-convex traces on plan.

Satellite images indicated that some landslides had long lobate forms, suggesting that they were flow. One of them was Shechadientsu landslide 34 km northeast of Dujiangyan, occurring across the probable earthquake fault rupture. It was 1.5 km long with a maximum width of 250 m and an apparent friction angle of 22°. The top of this landslide area was a steep cliff of Precambrian granite, which failed to go down a small valley. The volume of the slope failure was estimated much less than the volume of the deposit. The small valley had sporadic patches of bedrock consisting of alternating beds of sandstone and mudstone of Triassic in age. The bedrock was covered by bluish grey, clayey, water-saturated debris, which was not disturbed and in turn covered by water-saturated brownish debris with rubbles. The landslide deposits had wrinkles on the surface and streaks of same color rock fragments. In addition, cross section near the distal part had clearly defined reverse grading, in which larger rubbles with a maximum diameter of 5 m concentrated at the surface part. These characteristics strongly suggest that valley-fill sediments mobilized by the earthquake and flowed down the valley, getting higher at the outer side

of the valley bent.
The largest landslide with an estimated volume of 1 billion m3 occurred on an outfacing carbonate rock slope, which had been preceded by gravitational deformation appearing as a ridge-top depression. The second largest one occurred on a smooth outfacing slope that had been undercut.