Geophysical Research Abstracts
Vol. 12, EGU2010-6643, 2010
EGU General Assembly 2010

Incorporation processes in volcanic rockslide-debris avalanches from field observations: implications on emplacement mechanisms

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Rockslide-debris avalanches associated with volcanic sector collapses are highly erosive phenomena. The amount of incorporated material is hard to estimate but the few data available suggest that it can easily reach 10 vol.% of the deposit. There are two major consequences of substratum incorporation on flow behaviour: 1) loss of kinetic energy by friction and 2) gain of potential energy as the volume increase. The efficiency of the erosive processes will greatly influence flow mobility. We present field observations on several debris avalanche deposits (DADs) in Ecuador (Chimborazo and Imbabura volcanoes), Chile (Taapaca volcanoes), and France (Monts Dore volcano) to illustrate how rockslide-debris avalanches incorporate substratum.

The most common process of substratum incorporation is piece-by-piece erosion. This appears as basal shearing features and has been found in most of the deposits. Nevertheless, the size of these erosion features varies greatly from place to place. We found very large sections of basal contact at Chimborazo DAD. Planar contacts on epiclastic, ash fall and fluviatile deposits in the distal region generally present minor erosion features (from several centimetres to few decimetres-long). Where the pre-avalanche topography is more rough, the shearing features are much larger (up to metres-long) and show evidence of the impact of the flow. We found pebbles from the substratum reduced to powder in the Monts Dore debris avalanche deposit about 35 km from the source. In this deposit, the presence of large megablocks (> 50 m-wide) in the mixed facies induces erosion of large blocks (> 5 m-wide) of unconsolidated conglomerate. Such erosive mechanisms appear to be energy-consuming.

However, piecemeal erosion is not the unique incorporation process. We also found in most of the deposits significant evidence of substratum fluidisation. The best example of substratum fluidisation was encountered at one site at Chimborazo DAD where a large amount (several tens of m3) of the Chalupas unconsolidated ignimbrite is injected 40 m-up into the deposit body. Fluidised sand and pumice injections (several centimetres-wide and metres-long) are also observed at Imbabura, Monts Dore and Taapaca DADs. Such an erosive mechanism appears much more energy-saving than piecemeal erosion.

In conclusion we show that incorporation processes are complex and controlled by the substratum nature and topography. It is important to note that low density and fine grained substratum layers such as unconsolidated ignimbrites, ash and pumice fall, and sand deposit can be fluidised by the overriding rockslide-debris avalanche. We expect that such substratum can enhance the flow mobility.