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The Genesis of Huascarán-like Sturzstroms – a new physical approach

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The unusual high flow velocities of sturzstroms consisting of rock, water, and glacier ice are not fully understood. During the Huascarán disaster, mean velocities between 360 and 400 km/h are well-proven. In September 2002 a comparable event (the Karmadon disaster) took place in Caucasus south of Vladikavkas (North Ossetia) and killed about 120 people. In both cases the sturzstroms were initiated from huge masses of rock and glacier ice falling/sliding down 1000 m and more. In both cases considerable quantities of ice from retreating glaciers were present at the feet of the slopes where the impacts took place.

The travel paths were several kilometres long and had rather low inclinations. In case of Karmadon, the talweg was about 18 km long and only 6-7 degrees steep. The mean velocity of more than 300 km/h was calculated from the (seismically registered) impact time and the moment of rupture of a high-voltage line near the Karmadon resort.

A series of hypotheses have been developed to explain the extremely high flow velocities of sturzstroms. Especially melting of ice from the impact has been claimed to provide the necessary water volumes for the flow. A convincing explanation for the velocities so extremely different from normal debris flows, however, is missing.

A new model is proposed which involves the formation of vapour during the impact of the sliding/falling mass. At the beginning of the Karmadon event, an initial volume of 60 M m^3 of rock and ice has been reported to have slid/fallen from the source slope. With a 60 % ratio of ice, the bulk density might have been about 1.6 tons/m^3

resulting in roughly 100 M tons of mass involved. The height of the crown of the slope is 4350 m, the altitude of the glacier at the bottom of the slope 3250 m. Thus the mass centre of the rock/ice slide should have been at about 3800 m. Assuming an almost free fall of 500 m the velocity at the moment of impact should have been 100 m/s (360 km/h) neglecting any kind of friction. The kinetic energy of 100 M tons travelling at a velocity of 100 m/s is about 150 * 10^{12} Nm (85 M MNm).

During the impact a great portion of this huge energy was certainly transformed into heat. Melting of ice is commonly considered to provide the water for the flow. The bowl-shaped impact zone should have prevented material and energy to escape to the sides except for the open valley downstream. Thermo-dynamic calculations show that it is quite possible to postulate the formation of vapour too from the impact resulting in an explosion. The expanding gas should have driven the rock and ice masses towards the only open margin of the system, the downstream valley.

At Huascarán, eyewitnesses reported a heavy explosion from the impact area and USGS workers recalculated the flight of huge boulders which travelled up to 4 km through the air. From these ballistic computations initial velocities of 850 km/h resulted which would be well in accordance with the vapour explosion hypothesis presented here.