T1-004

Grain-size Distribution Change at Unzen Volcano & Impact on Lahar Triggering and Flowage
雲仙火山に於ける粒径変更：ラハー発生と流れ方の影響

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Introduction and objectives

Regular, high-frequency debris-flows carving the slopes of volcanoes are termed lahars, and they have been mostly studied during and in the aftermath of volcanic eruption as their rates guaranty observations. However, when they are more scarce and alternate with other slope processes, the relative role of one process over another is far less understood. Moreover, as the material changes over time, it will impact the runout of debris flows, as it has been shown by laboratory experiments [1,2].
The objectives of this research are to (1) characterize the grain-size distribution variations from different sources of material available in the Gokurakudani, in order to (2) measure the type of material available for lahar triggering, (3) how it differs and (4) how this differentiation occur.

Field location and Method

The present research was conducted in the Gokurakudani Valley, at Unzen Volcano, during the period 2016-2018 (Fig. 1), for a research project funded by the MLIT and supported by the Unzen Restoration Work office.

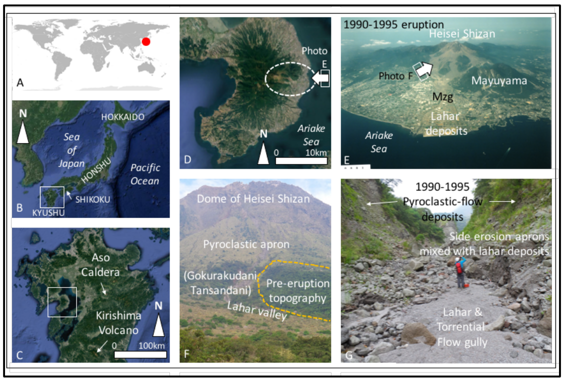

Fig. 1 Location of Unzen Volcano and the Gokurakudani, on the Southeastern flank.

The method consists of in-situ drying, sieving and weighing of the different sediment sizes, in the Gokurakudani-valley. The method employed was dry sieving with a reduced number of sieves (0.0625 mm, 0.125 mm, 0.25, 2 and 4 mm). As the material contains virtually no organic matter, the sediments were not cleaned with hydrogene peroxide 10%, as it is usually suggested to remove organic matter.

Material resistance to shock and abrasion characterization was also estimated using the rebound from the Schmidt Hammer on the different blocks found in the valley (dome segments from the Heisei eruption, older dacite (red and altered) and Quaternary welded pyroclastic tuff (white bedrock).

Results

Change of lahar source materials

Lahars that ran over the 1990-1995 deposits encountered layered pyroclastic flow deposits with an alternation of coarse-grained layers rich in fines (<0.0625 mm) but enclosed in a gravel matrix (40% >2 mm – Fig. 2). Those layers alternated with thinner ash-fall deposits. This source of material has changed as the gullies started to be fed by remobilized material, where mid-size material is transiting in the valley through different erosion/deposition processes, but washing the fines away from the valley in Newtonian fluviatile events. This is further reinforced by the oozing effect of fine material being washed out from the pyroclastic flow deposits, as attested by the drapes found on the outcrops, having a significant finer grain-size (Fig. 2).

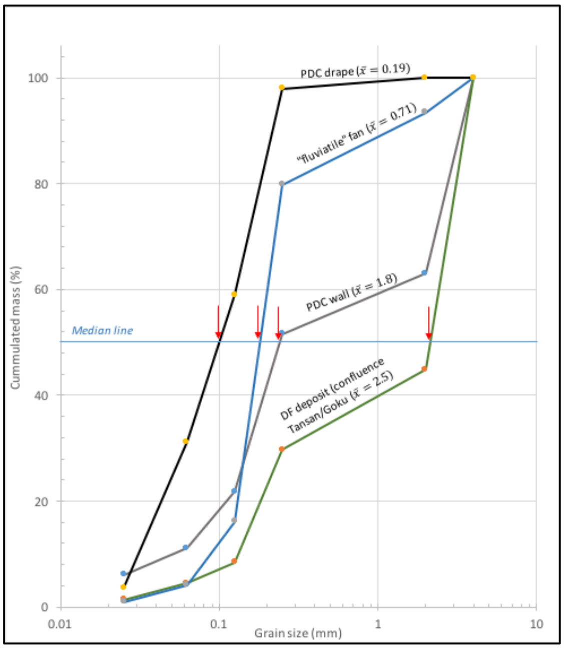

Fig. 2 Grain-size distribution of different formations in the Gokurakudani Valley.

Consequently, as the fines are being washed off the gully floor and from the outside sections of the ignimbrites, the further in time from an eruption, the less the numbers of lahars, and the less rich in fine material they are. This is corroborated by the video observations made in the Gokurakudani Valley.

Change in the availability of material type and resistance to point load.

As the gullies are carving their ways vertically through the pyroclastic material left in the aftermath of the 1990-1995 eruption, the valley floor and the heads that progressed by regressive erosion are presently eroding the original material underneath made of pyroclastic tuff and Quaternary dacite. The material resistance to erosion, collision and impacts is therefore different depending on its origin and this was shown by using rebound data from the Schmidt Hammer. Surface-perpendicular rebounds on the 1990-1995 dacitic blocks range between 38 to 62, older altered red-dacitic blocks show rebound 30 to 42 (Fig. 3).

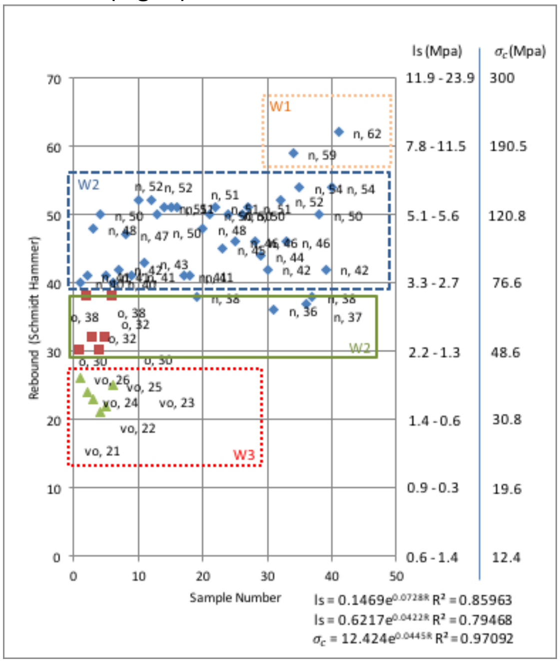

Fig. 3 Schmidt Hammer rebound value for each sample (Green triangle: Quaternary dacite; Red square: Historical eruption; Blue diamond: Heisei eruption), with equivalent point load strength (ls) and unconfined compressive strength (σ_c), corresponding to the weathering grades W1, W2, W3 and W4 [3].

At the head of the Gokurakudani gully, Quaternary dacite shows a rebound < 26 while the blue color (manganese alteration) dacitic material was too brittle to perform effective Schmidt Hammer testing. This data corresponds to a six to ten-folds relationship in term of compressive strength ranging from 31 to 196 MPa and in term of load strength from 0.6 or 1.3 to 8.5 to 1.3 Mpa (value ranging based on two models).

Discussion

As demonstrated by [1], the fine matrix ratio change in debris flows/lahar modifies the flowage and the longitudinal reach of the events. Furthermore [2] also demonstrated that gravel-size material combined with fines reach an optimum combination for maximum runout with clay fraction 0.05 to 0.2, and gravel fraction 0.25 to 0.5. At Unzen, change in material is also accompanied by modified abilities to fraction during the flow, as the strength of the material decreases, lahars will slim their population of large blocks down and transform them into smaller fractions. At the same time, the amount of original fines is being depleted through other forms of erosion as shown by the drapes on the outcrops.

Conclusion

As the relative distributions of material and the resistance to load and shear vary over time, one should consider the long-term evolution of the landscape after a major event to scale and design “Sabo” dams and plan for countermeasures. This can be one of the explicative element in the regain of lahar that ran in the Gokurakudani and the Tansandani [4].

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