（様式３）

新潟大学災害・復興科学研究所
共同研究報告書

The Spatio-temporal control of pumice vesicularity on lahar disaster risks (ラハール災害リスクにおける軽石発泡度の時空間変化による制約)

Christopher GOMEZ [1)]
Kyoko KATAOKA [2)]

[1)] Kobe University, Graduate School of Maritime Sciences
[2)] Niigata University, Research Institute for Natural Hazards and Disaster Recovery
(Collaborating Partner)

研究要旨

The state of the art in debris flow, hyperconcentrated flow and their volcanic equivalent, lahars, has been developed from theory and fieldwork where the material is clastic (i.e. non-volcanic) and with a higher density than the interstitial fluid. However, hydrological remobilization of pumiceous ignimbrites can generate flows that escape those traditional models.

Using material produced by Numazawa Volcano, the present research aimed (1) to measure the rate of water incorporation in the dry material, while at rest and when in movement, (2) and to measure abrasion rates in a flow.

The method relies on a series of benchtop experiments, measuring the mass change after various period of immersion in either still water or turbulent water.

The result shows that water incorporation is asymptotic and after a rapid entry in the outer layer, the incorporation rates slows exponentially. This is consistent with the physical model of plume, contaminant, and groundwater through a porous media, where the progression follows a model of the format $\partial D/\partial t = \propto.\nabla^2 .D$ where D is the diffusion rate, ∇^2 is the Laplace operator, $\propto$ is the diffusion coefficient and t is the time. Results from material in movement show that the relation does not hold through however. As the pumice clasts increase in mass and gain momentum during flow transport, they start to loose mass by abrasion once a critical threshold of momentum is reached (either by velocity increase or by mass increase).

A．研究目的

The research objective has been the measure of the change in the “volcaniclastic sediment load “having variable grain density such as pumice under a sediment-laden flow condition with an example of a gigantic outburst flood event that swept the Tadami River and Agano River (Kataoka *et al.,* 2008). The flood with a total discharge of 1.6 km^3 was derived from a break of temporal dammed lake formed by the ignimbrite emplacement to the Tadami River valley at Numazawa Volcano, Also, this research aims to (1) measure the water absorption rate of the pumiceous material when it is at rest, representing the water absorbed by the temporary ignimbrite dam that barred the

Tadami River valley and (2) to estimate the water absorption and pumice abrasion during flow transport.

B．研究方法

The methodology relies on laboratory testing of pumiceous material of coarse sand size to cobble size at different locations along the valley and at existing outcrop and quarries along the Tadami River and Agano River (fig. 1).

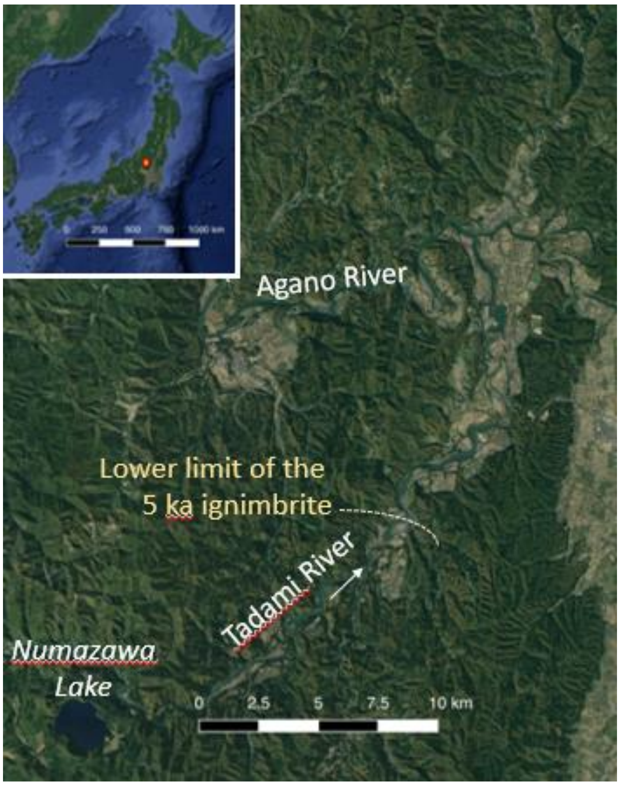

Fig. 1 General location of Numazawa Lake and the Tadami River and Agano River from where the outburst flood travelled down to the Niigata plain, about 150 km downstream.

In the laboratory, a first set of sample was cut into rectangular shape for absorption rate experiments: 1) by capillarity absorption and 2) kept as a whole for full size absorption, by plunging the samples in water. The samples were plunged into the water or left in capillarity contact for series of 10 seconds periods and then weighed using a Metler Toledo weighing machine with a calibrated 0.001 mg precision. After each plunge, the samples were kept one to two seconds above the water to remove the capillary water at the surface. The experiments were repeated for each sample 6 times to have results over the first minute of absorption. The work was then repeated over longer period of time, with a measure every 2 days during a two-weeks period.

In a second time, to simulate the incorporation of water in pumice during movements, a second series of measure was performed using a mixer in a 1-liter size beaker (Fig.2)

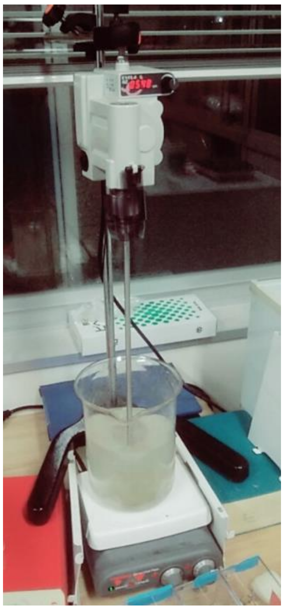

Fig.2 Mixer and beaker used to test the water incorporation in the pumice during the flow. The mixer has a regulator that allows the control of the angular velocity. The apparatus was plunged in the upper part of the beaker to avoid any contact with the rotating pumice clasts during operation. In the glass beaker, the boundary roughness has been disregarded as a potential source of abrasion.

C．研究結果

The results show that the water incorporation rate in the pumice is a function of the vesicularity and the size of the pumice. As the sampled chosen had a comparable vesicularity, it yields that the wet mass of the pumice after one minute is a linear function of the dry mass of the pumice, with a good correlation (Fig. 3).

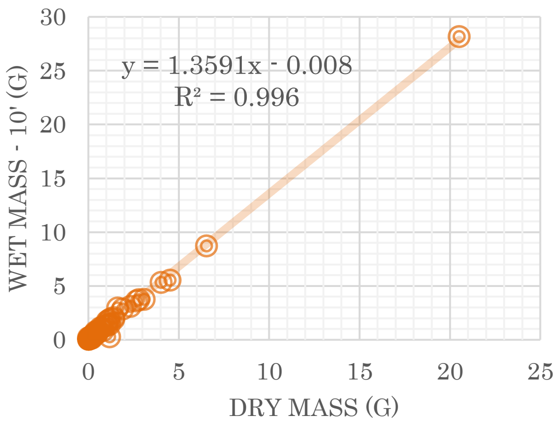

Fig. 3 Relation between dry and wet mass after one minute in water.

This correlation inverses for pumice that has been plunged in flowing turbulent water for several minutes. The test on a 14.8 g pumice at time 0, with water absorbed over a 2-weeks period, shows that its mass decreases to 14.5 g at 80 minutes, 14.35 g at 140 minutes, reaching 14.2 g at 200 minutes (3h20 min). It follows a linear relation, showing a progressive abrasion.
This abrasion of the pumice has been tied down to two different factors such as 1) the presence of glass shards in the water that "erode" the pumice clasts and 2) the contact between the pumice clasts, "rubbing" one against another.

D．考察

The present research indicates that (1) the water incorporation in the pumice can be considered as a function of the size of the material. Therefore, the grain size and sorting of the material will have an important role on how fast the water is being absorbed.
(2) The mass increase occurs when pumice is at rest and/or when a threshold momentum is not reached. Passing this threshold, the mass decreases again by abrasion.

This phenomenon should therefore be considered for hazard analysis, as the maximum momentum will not be reached due to a geomorphologic or rheological control but due to the time the material property (the mass) changes.
Secondly, it also suggests that the material size at the start of a given single flow will be very different from the one at the end, with abrasion occurring much faster than in clastic equivalent. This can thus explain the rapid transport of material over long distance.

Existing models of debris flows and hyperconcentrated flows are therefore not adapted and there is a need to develop new simulation methods to account for the peculiarities of pumiceous sediment-laden flows.

E．結論

Pumiceous hyperconcentrated flows have a complex rheology with modification of the mass of the "volcaniclastic sediment-load", meaning that for a given slope of energy, or even a regular topography, the deposit and the flowage of the material will display complex behaviours.

F．研究発表

1. 論文発表 （掲載誌名･巻号･頁･発行年を記入し，

なし

2. 学会発表 （学会名・発表年月・開催地なども記入）

Gomez, C., Kataoka, K. 2018. Differentiating Transport Mechanism of Pumices in Hyperconcentrated-flows from Numazawa Volcano-Japan. Japanese Geophysical Union Meeting, Makuharimesse, Japan, May 20th–24th.

G．知的財産権の出願・登録状況（予定を含む）

なし