British Geological Survey

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Insights from distal ash fall on grainsize of volcanic ash in the atmosphere

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INTRODUCTION

Accurate description of the physical characteristics of volcanic ash is crucial for assessing ash dispersal during a volcanic eruption. The grainsize of ash emitted during an eruption is dependent on the type and dynamics of the eruption. The grainsize at any location in the atmosphere is a function both of the initial distribution of ash, and complex interaction between eruption (e.g. plume height), depositional and atmospheric (e.g. wind) dynamics. Here information from deposits from a range of eruptions, is used to investigate key controls on grainsize of ash in the atmosphere.

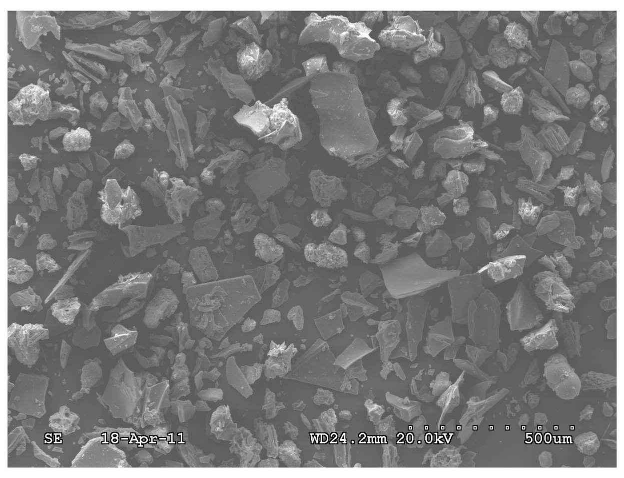


FIGURE 1. SEM image of CI ash from 1230 km from source.

THE CAMPANIAN IGNIMBRITE ERUPTION

The Campanian Ignimbrite (CI) eruption occurred near the Bay of Naples 39 kya, and dispersed ash (Figure 1) to distances of more than 2300 km from source. Visible ash layers are preserved in subaerial, lake and deep sea cores, and the grainsize of these deposits was analyzed to identify changes in grainsize with distance. The deposit is bimodal to distances of approx. 900 km, whereby it becomes unimodal (Figures 2 and 3). At distances greater than 900 km, there is very little change in grainsize, with deposits from a range of different depositional environments having similar distributions, despite large differences in distance from source (Figure 4).

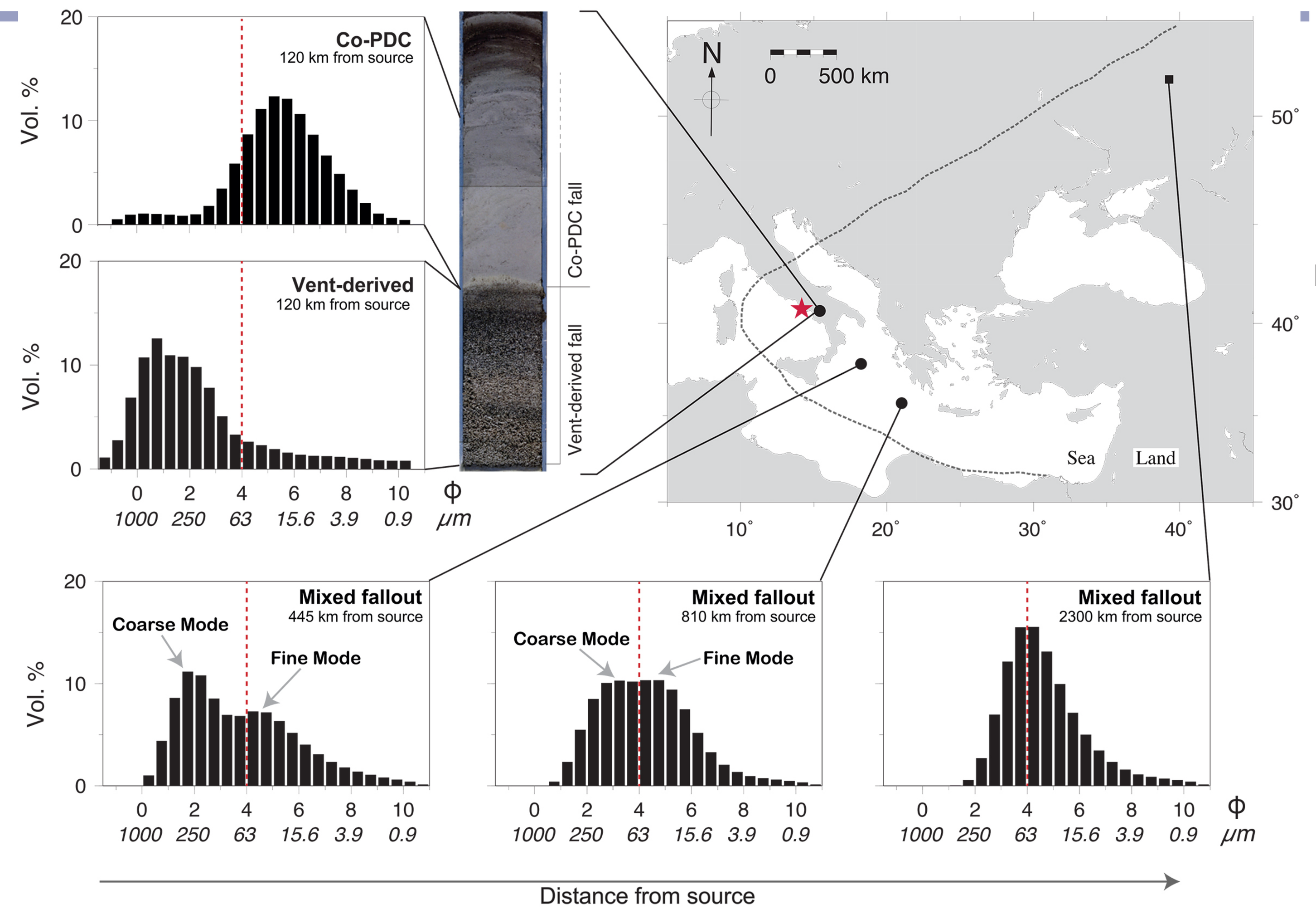


FIGURE 2. Grainsize characteristics and dispersal extent of deposits from the Campanian Ignimbrite eruption (from Engwell & Eychenne, accepted)

FIGURE 3. CI Mode with distance from source (Engwell et al. 2014)

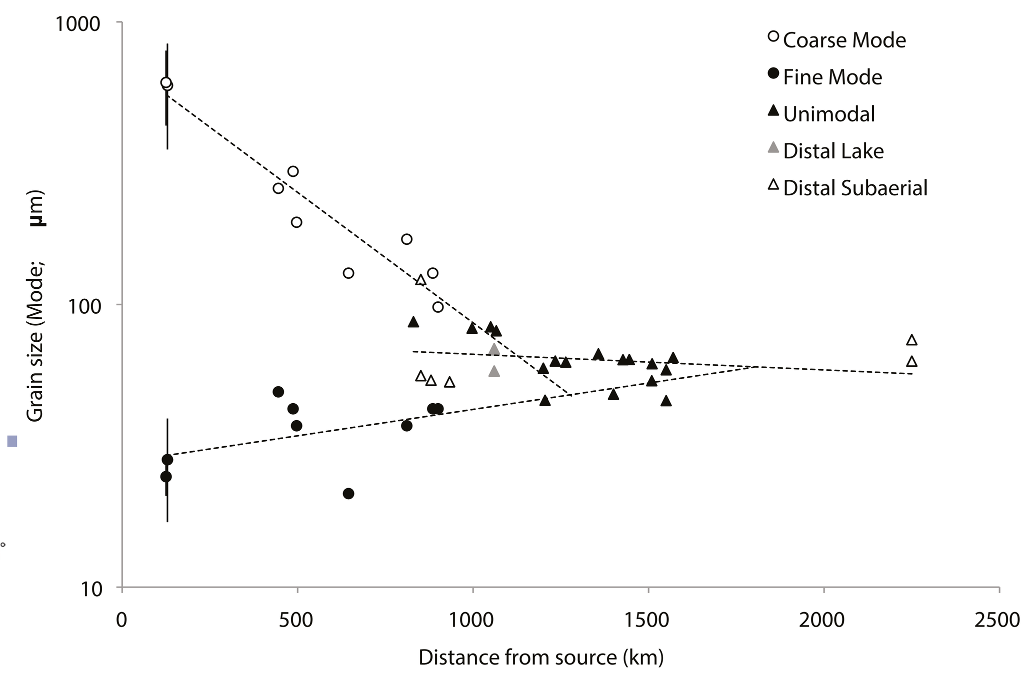
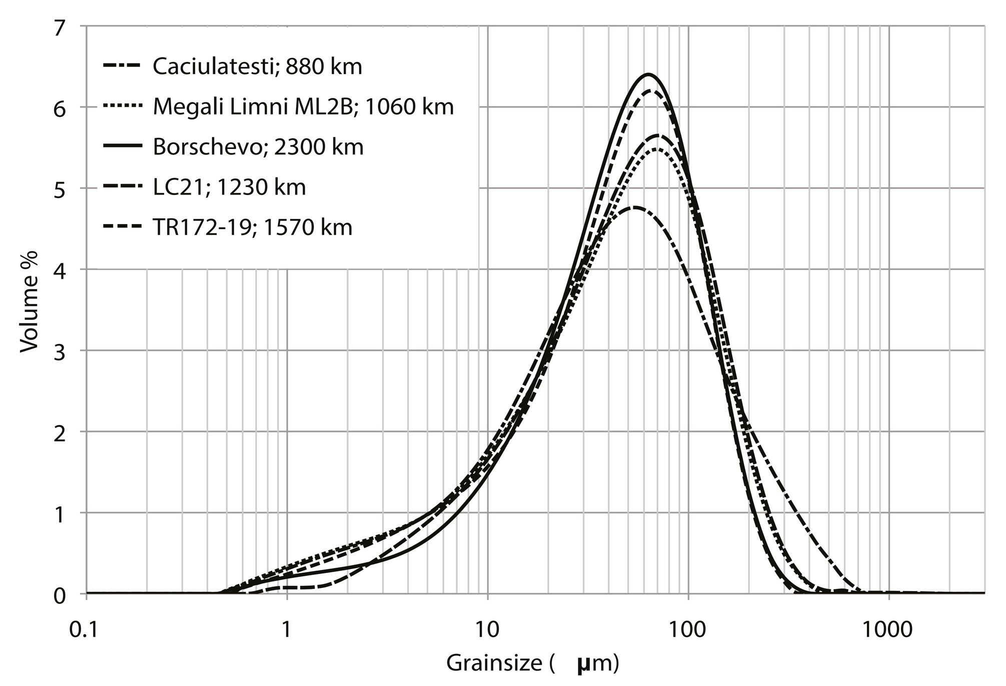
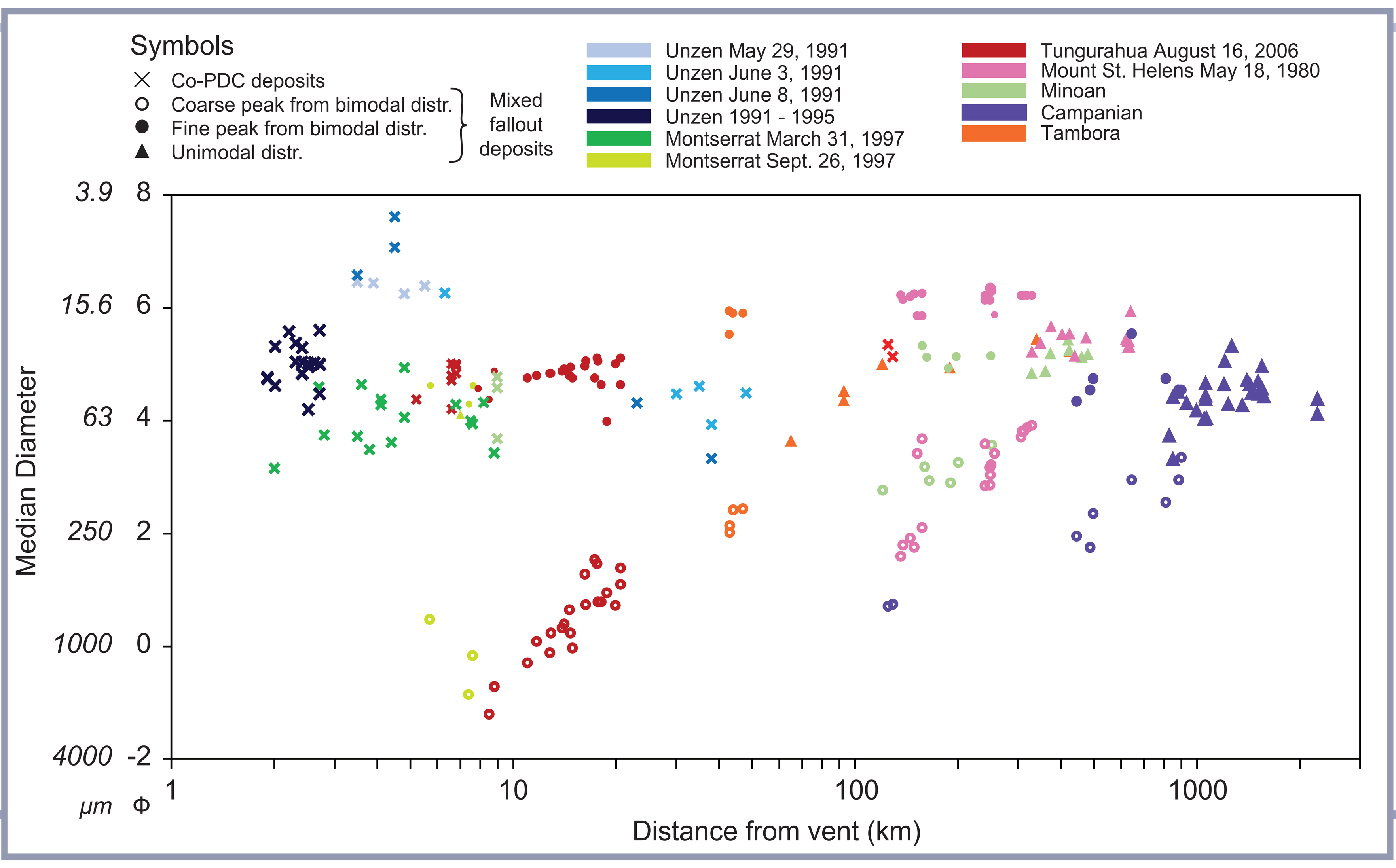


FIGURE 4. Grainsize distributions of distal CI ash (Engwell et al. 2014)





DEPOSIT GRAINSIZE

Comparison of grainsize trends from a number of eruptions of different types and magnitude (Figure 5) show similar changes in grainsize with distance:

- A decrease in coarse mode
- Uniform fine mode, where present
- Distal unimodal deposits have remarkably consistent characteristics over large distances

These trends imply that while coarse particles settle according to their terminal velocity, depositional processes for fine grained ash are considerably more complicated. The consistent grainsize with distance from source, and for a large range of eruptions indicates that the dominant control on deposition of particles of approx. 60 microns is concentration, rather than terminal settling, and that this ash is preferentially retained in the atmosphere.

FIGURE 5. Median grainsize with distance from source for a number of eruptions (modified from Engwell & Eychenne, accepted)

TERMINAL VELOCITY

Volcanic particle transport and deposition is strongly influenced by their typical irregular shape at all scales (Figure 6). Shape can be characterized by different methods (Optical, Micro-CT, SEM, etc. Figures 7 and 8) and is a key consideration for estimation of particle terminal velocity, w_t:

$$w_t = \sqrt{\frac{4gd_p(\rho_p - \rho)}{3C_d\rho}}$$

Where the drag coefficient C_d is a function of particle Reynolds number and shape, g is gravitational acceleration, d_p is the diameter of the particle, ρ_p is the density of the particle, and ρ the density of ambient.

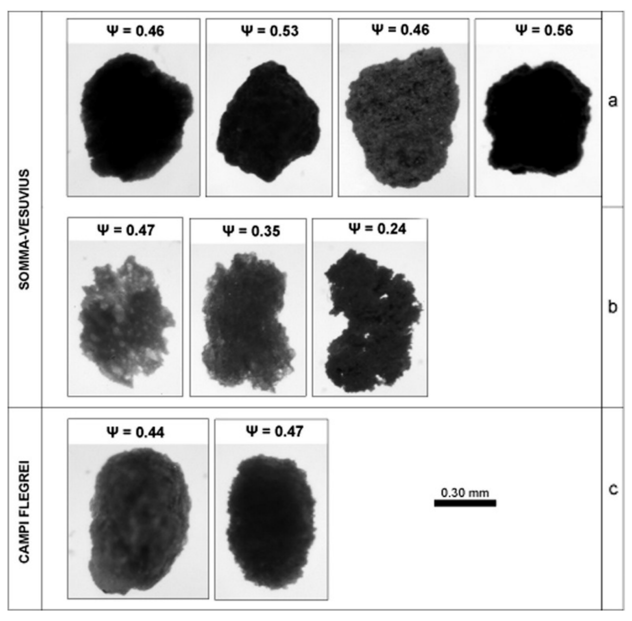


FIGURE 7. Optical method of characterizing shape factor (Dioguardi and Mele, 2015)

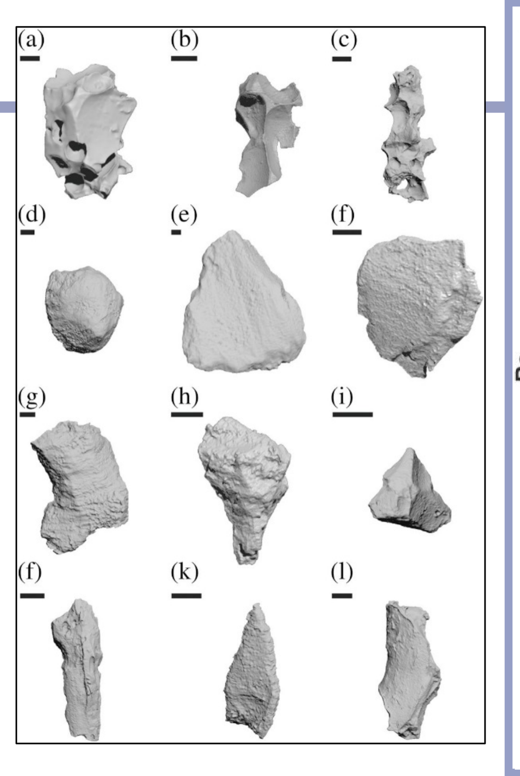


FIGURE 8. SEM Micro-CT method for shape characterization (bar length equals 0.1 mm; Bagheri et al. 2015)

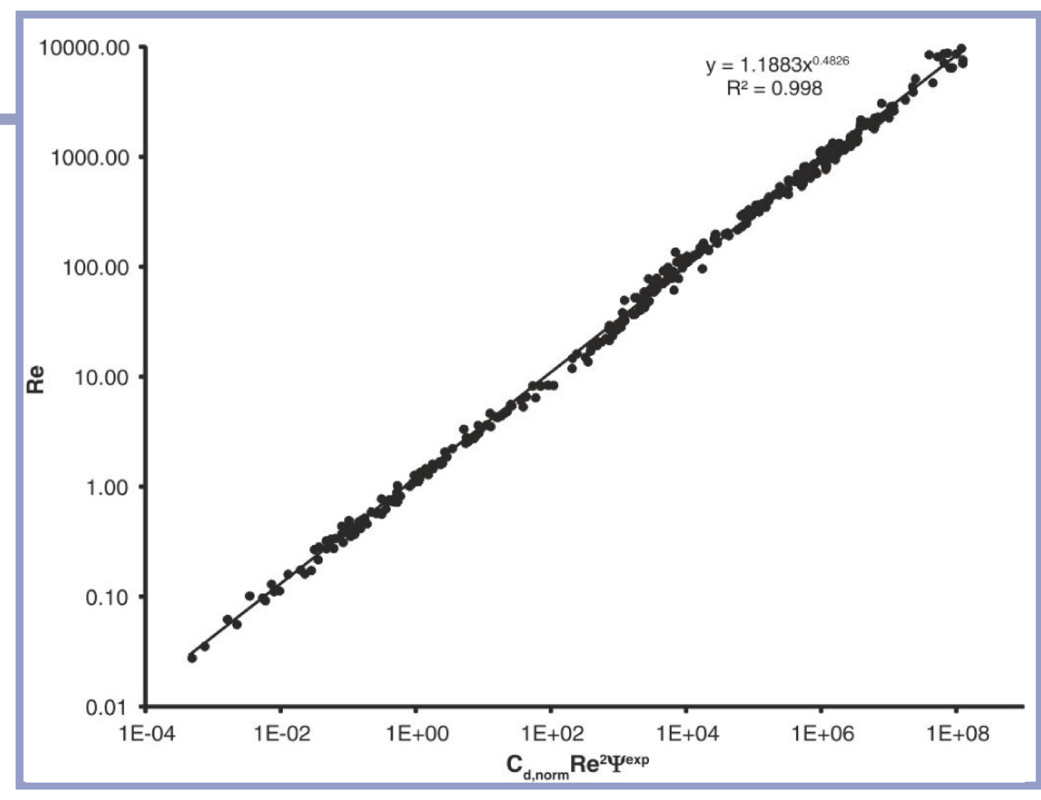


FIGURE 6. Data from settling experiments showing the non-linear dependency between particle terminal velocity, drag and shape (Dioguardi and Mele, 2015)

THE GLOBAL VOLCANO MODEL (GVM) - a platform for volcanic hazard and risk information

GVM is a growing international network that aims to create a sustainable, accessible information platform on volcanic hazard and risk. GVM provides systematic evidence, data and analysis of volcanic hazards and risk on global, regional and local scales, and will develop the capability to anticipate future volcanism and its consequences. The network is designed to provide global volcanic risk information to governments and international strategies for disaster risk reduction (DRR), in order to inform local, national, regional and international policy on volcanic risk reduction and resilience building.

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