Characterising Pyroclastic Density Current Grainsize Data

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Grainsize in volcanology

Grainsize data is a key source of information for characterising volcanic eruptions and process, both for volcanic plumes and flows. For a given eruption, grainsize can provide insight into eruption and process dynamics, including initiation mechanisms. Comparison of grainsize characteristics from different locations within a deposit or from multiple deposits provides insight into controlling transport and depositional mechanisms. Here, we present results from an analysis of pyroclastic density current (PDC) grainsize information from the published record (Table 1).

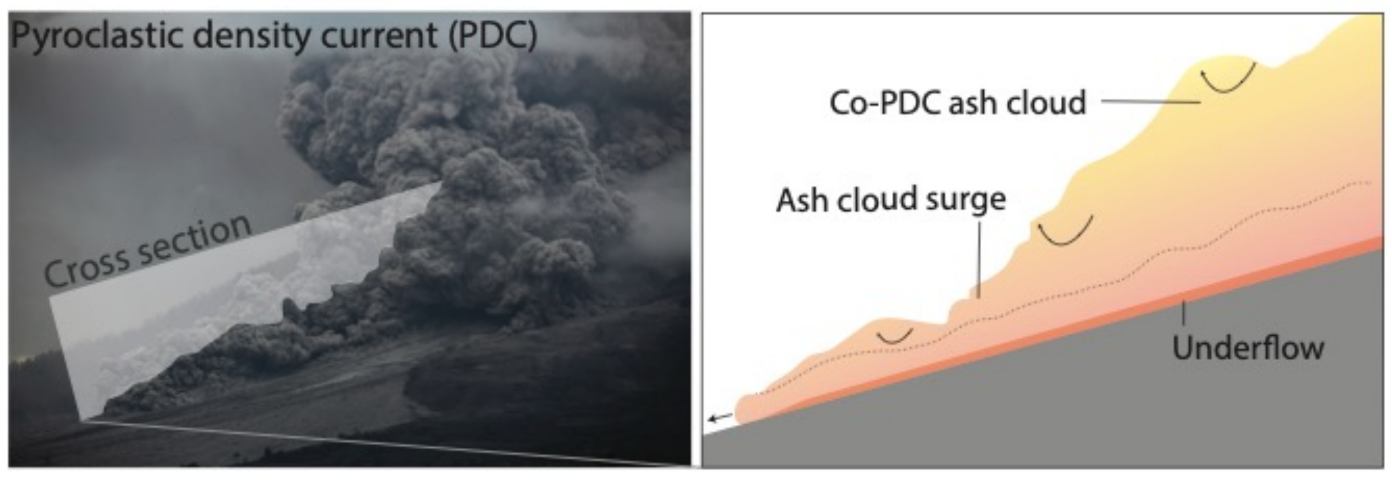

Figure 1. Image and conceptual structure of PDCs showing dense and ash cloud surge (modified from Lube et al. (2020)).

Pyroclastic Density Current Deposit Grainsize

PDC grainsize distributions have a wide range of forms depending on the flow type. Distributions from dilute flows (surges; Figs 1 and 2) tend to be relatively simple, with one dominant mode. In comparison, dense flows (Fig 1, e.g. block and ash flows) are multimodal and very poorly sorted, containing both fine ash and very coarse blocks (Fig 2). This range in grainsize makes measurement of the full grainsize distribution near impossible: it is not possible to accurately measure the contribution of both the finest and largest clasts in the field resulting in truncated distributions, where the distribution apparently cuts off at distribution ends. The number of modes within a distribution relate to both transport processes and flow componentry, thus providing further information on flow characteristics.

Table 1. List of Volcanoes and References from which PDC grainsize distribution used in this study

Volcano	Reference	Volcano	Reference	Volcano	Reference
Nevado de Toluca	Arce et al. 2003	Mt St Helens	Mellors et al. 1988	Kelud	Maeno et al. 2017
Bezimianny	Belousov et al. 2002 Belousov et al. 2003	Nakadake, Aso	Miyabuchi et al. 2006 Miyabuchi et al. 2018	Vesuvius	Sulpizio et al. 2010 Walker 1979
Chachimbiro	Bernard et al. 2014	Unzen	Miyabuchi 1999	Calbuco	Castruccio et al. 2016
Merapi	Schwarzkopf et al. 2005 Boudon et al. 1993 Bourdier et al. 2001 Bourdier et al. 2002 Boudon et al. 1993 Charbonier et al. 2011	Soufriere Hills, Montserrat	Ritchie et al. 2002 Cole et al. 2002 Stinton et al. 2014	Colima	Saucedo et al. 2004 Saucedo et al. 2002 Saucedo et al. 2010
Aira Caldera	Kano et al. 1996	Quilotoa	Mothes and Hall 2008	Campi Flegrei	Walker 1979
		Atitlan	Walker 1979		

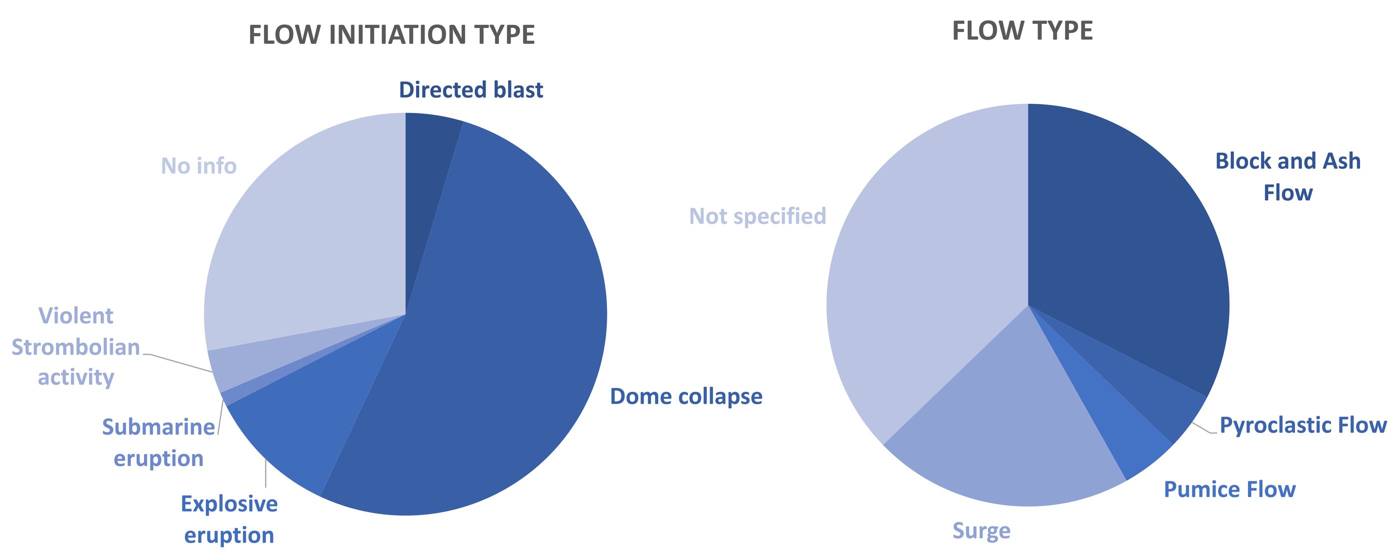

Figure 3. Flow initiation and flow type characteristics within the grainsize dataset.

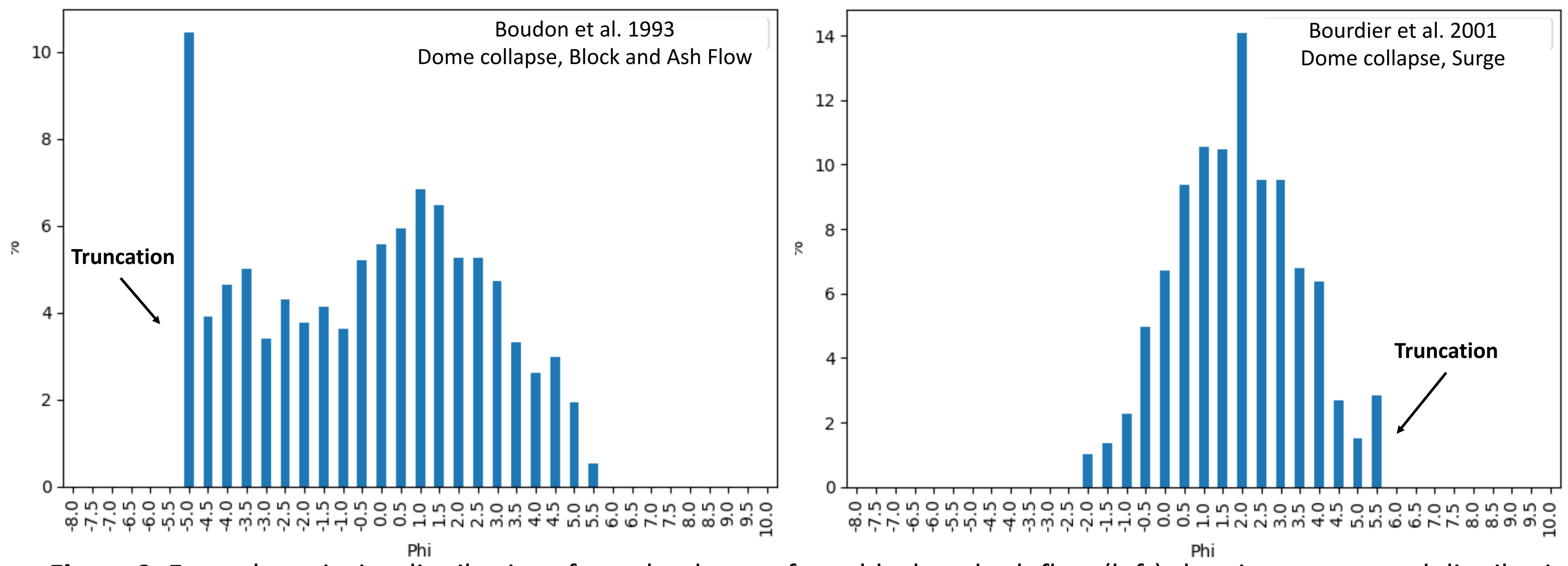

Figure 2. Example grainsize distributions from the dataset for a block and ash flow (left) showing a truncated distribution, and a surge (right).

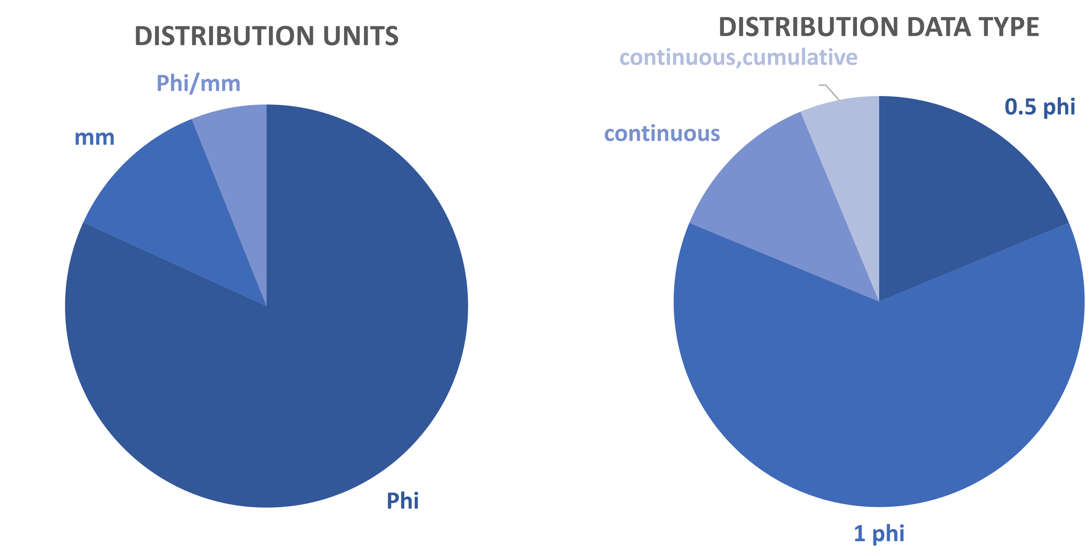

Figure 4. Units and distribution and bin type of data within the dataset.

Grainsize Dataset

Grainsize distribution data from 28 publications relating to 30 eruptions at 16 volcanoes were collected (Table 1). The predominant source mechanisms for the PDCs in the dataset is dome collapse (Fig 3) and where specified, the dominant flow type is block and ash flow (Fig 3). In total, 335 grainsize distributions were collated, in addition to meta and descriptive data including:

- Bin size and type
- Max and min grainsize
- Measurement units (phi (*phi = -log2(mm)*) vs mm, Fig 4)
- Distribution presentation type (continuous, binned, cumulative data, Fig 4)
- Available statistics (median, sorting coefficient, etc)
- Presence of truncated distributions (e.g. Fig 2)

This information was interrogated to inform use of grainsize data from multiple different publications. Distributions within 68 % of the publications were truncated, while median and sorting coefficient are the most commonly presented statistics.

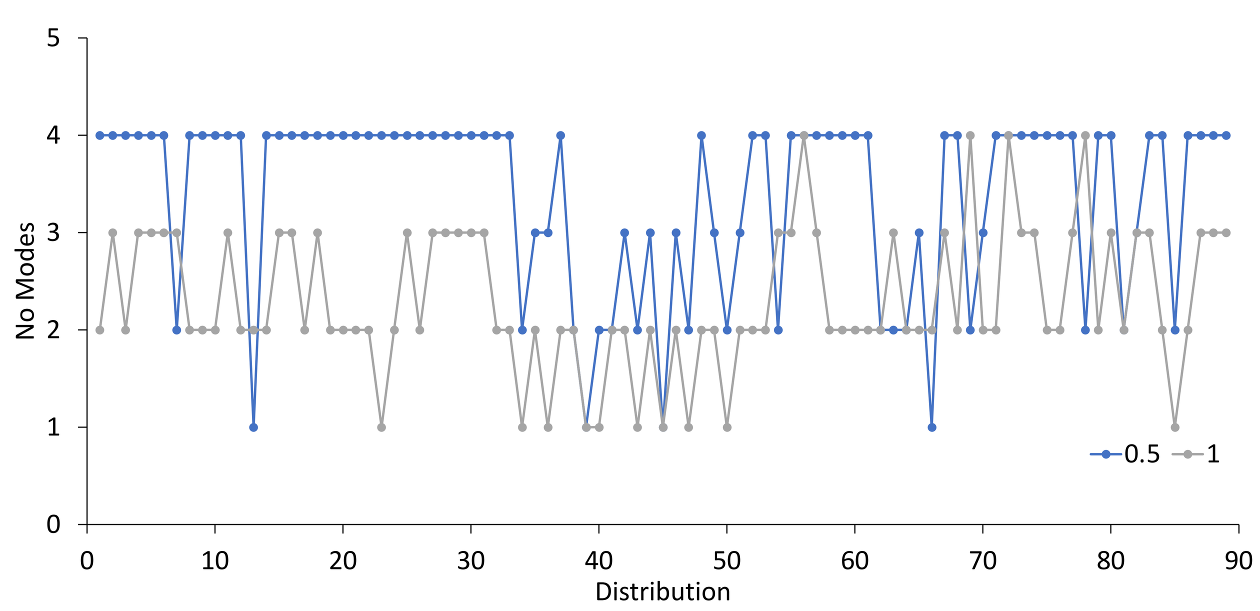

Figure 5. Comparison of number of modes defined by GRADISTAT (Blott et al. 2001) when data in half phi versus one phi bins where each point represents one distribution

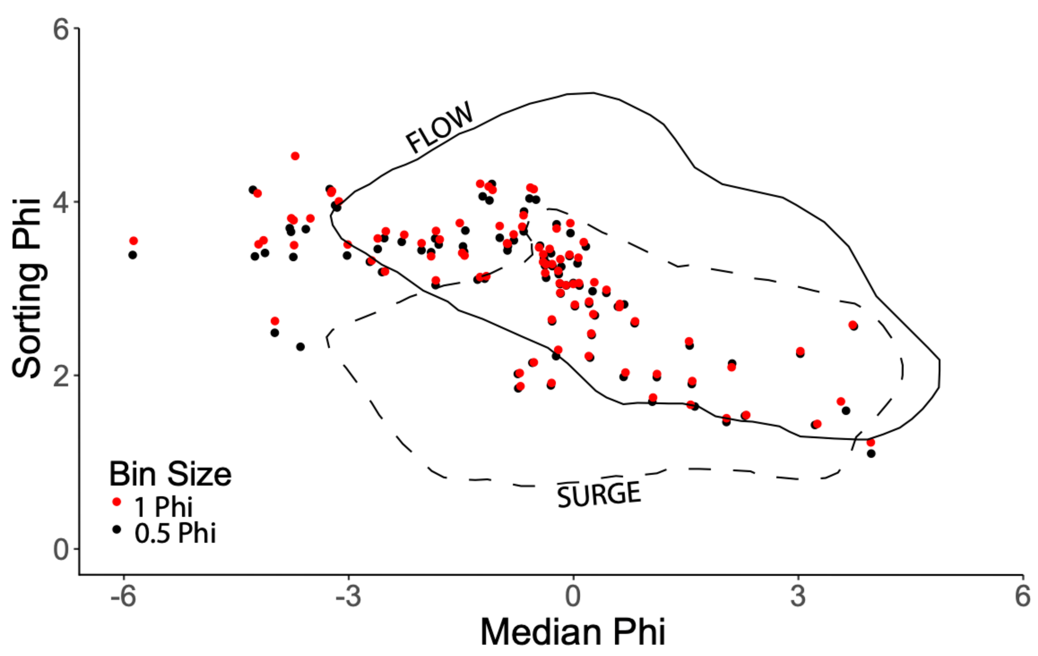

Figure 6. Sorting and median calculated in GRADISTAT (Blott et al. 2001) for grainsize data in half phi and phi bins. Flow and Surge contours from Walker 1983.

Impact – an example: Bin Size

Use of different bin sizes is common in presentation of PDC grainsize information (Fig 4). One phi, in comparison to half phi bins often results in identification of fewer modes (), which could affect interpretation of distributions in terms of flow process (Fig 5).

The impact on sorting and median is however negligible (Fig 6), which means that different bin sizes do not have a large impact when comparing this data from different eruptions and studies.

Conclusions

Various methods and approaches are used in the measurement and presentation of PDC grainsize data. PDC grainsize data are limited in that distributions are often truncated, meaning information at the coarse and fine tails are lost. Differences in presentation (e.g. different bins and units) make direct comparison of data across studies and deposits difficult and impacts data interpretation.

Any use of data from the published record requires careful capture of data characteristics, but the richness of data in the record (Fig 6) means that there is great potential for understanding process. Our next steps are to further interrogate the data, and investigate the application of statistical measures used in other fields to better describe PDC grainsize data.

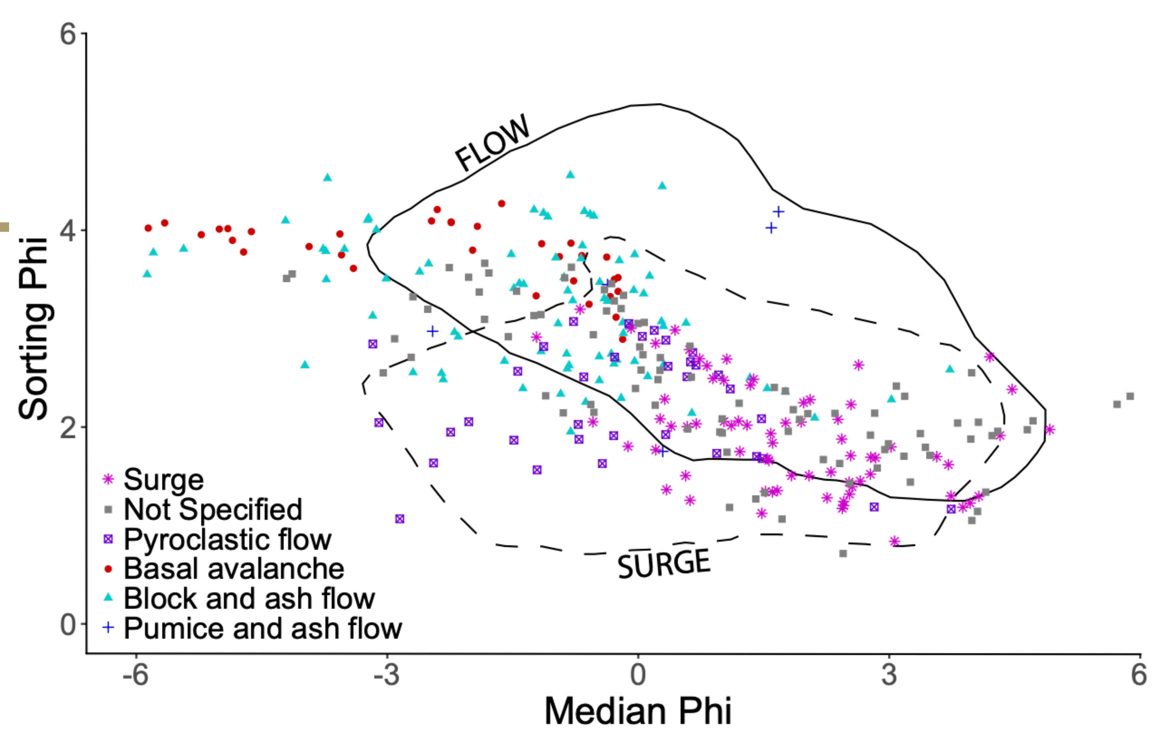

Figure 7. Sorting and median for all data collected. Flow and Surge contours from Walker 1983.

Blott et al. (2001), Boudon et al. (1993), Bourdier et al. (2001) * Blott, S.J. and Pye, K. (2001) *Earth Surface Processes and Landforms* 26, 1237-1248 * Boudon, G., Camus, G., Gourgaud, A. and Lajoie, J., 1993. *Bulletin of Volcanology*, *55*(5), pp.327-342. Bourdier, J.L. and Abdurachman, E., 2001. *Bulletin of Volcanology*, *63*(5), pp.309-325.* Lube, G., Breard, E.C., Esposti-Ongaro, T., Dufek, J. and Brand, B., 2020. *Nature Reviews Earth & Environment*, *1*(7), pp.348-365. * Walker, G.P., 1983. Journal of volcanology and geothermal research, 17(1-4), pp.65-88. Please email sameng@bgs.ac.uk for full list of references in Table 1.