Grain size analyses

Meaning

Grain size analyses allow obtaining the size and distributions of the non-welded and unconsolidated pyroclastics emitted during an explosive eruption. These quantifications in turn provide:

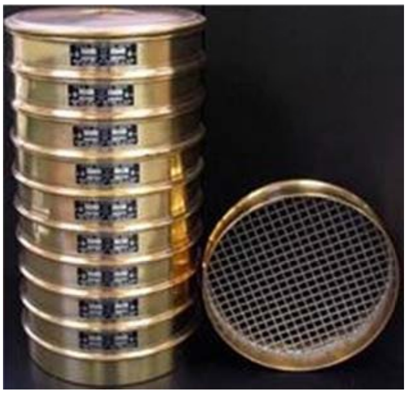
- Size distribution, degree of sorting and skewness of the sample Inman (1952) and Folk and Ward's (1957).
- Fragmentation characteristics of the associated explosion
- Genetic interpretation of the pyroclastic deposits (Sheridan 1971, Walker 1971)
- Classification of the volcanic events (in combination with the dispersion of the deposit)
- Mean velocity, competence and capability for diluted pyroclastic density currents

Requirements

The sampling has to be representative of the deposit, so the quantity to collect can vary between 200-3000 gr

Methodology

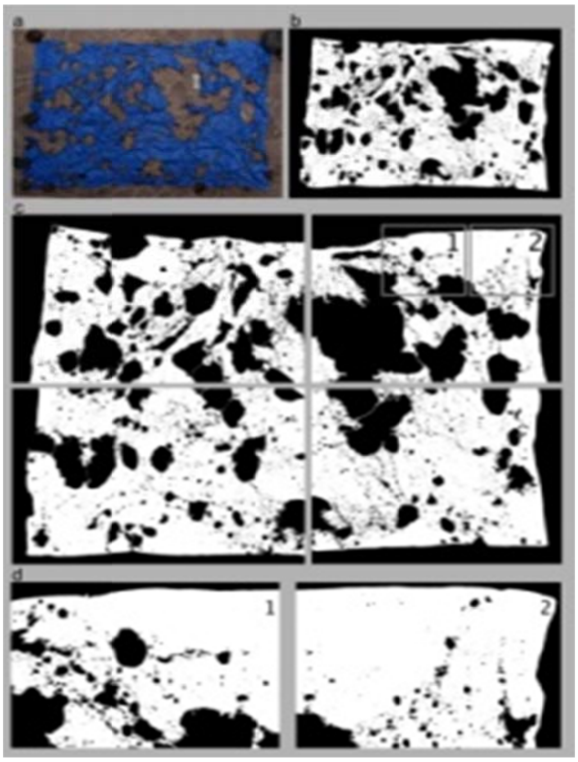
Mechanical grain size analyses



The classical granulometric analyses have been described by Walker (1971). Analyses are made with a set of sieves with mesh sizes spaced at one- or half-phi intervals, where phi = -$\log_2 d$, d being the grain diameter in mm, and ranging in size from -6 to 4 phi. The sieves are arranged in downward decreasing mesh diameters. The sieves are mechanically vibrated for a fixed period of time. The weight of sediment retained on each sieve is measured and converted into a percentage of the total sediment sample. This method is quick and sufficiently accurate for most purposes. Essentially it measures the maximum diameter of a sediment grain. Both graphic and statistical methods of data presentation have been developed for the interpretation of sieve data. The percentage of the samples in each class can be shown graphically in bar charts or histogram. Another method of graphic display is the cumulative curve or cumulative arithmetic curve. The four statistical measurements for sieved samples consist of a measure of central tendency (including median, mode, and mean); a measure of the degree of scatter or sorting; kurtosis, the degree of peakedness; and skewness, the lop-sidedness of the curve. Various formulae have been defined for these parameters the set of formulae we will use will be Inman (1952) and Folk and Ward's (1957).

Tarp-derived grain size analyses

Recently, we have developed a new sampling strategy to collect pyroclasts in active balistc and/or fallout fields, using network of large (3 × 2 m) plastic sheets (tarps) to record the sizes, the masses and distribution of bombs landing on them. These tarps are general purpose tarpaulins (tarps for short), 5-6 mm thick, and manufactured from low density polyethylene. When the conditions are favorable and the explosion is not too energetic, the tarps can retrieval and the grain size can be made directly on the pyroclasts landed on the tarps.

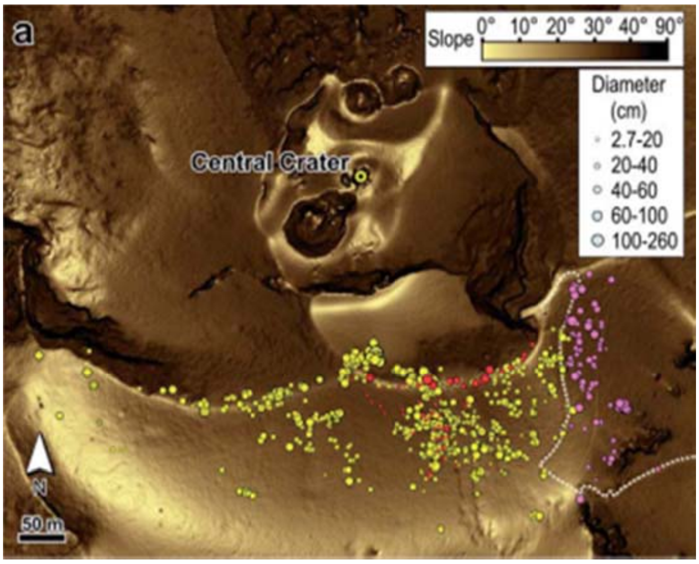


During June 2008, an experiment was deployed at Stromboli with the aim to better define magma fragmentation process associated with the normal activity by sampling a single explosive event. The set of samples were collected using a. These were. The plastic sheets were deployed just few

However, in certain special conditions, hot volcanic scoria bombs landing on the tarps can burnt the plastic generating holes. We proved that the pattern on burnt/un-burnt surface provided a map with which coarse grained clast distribution could be reconstructed (Colo et al in review). Ash and lapilli that land on the plastic sheets, because of their low weight and small size, do not leave any holes because of their short cooling time. Consequently, they need to be sampled directly for the tarp (Harris et al 2013). Photos showing the bomb distribution and dispersion on each plastic sheet, were taken before their retrieval. Then, once retrieved, digital photo mosaics, taken at different magnifications, were created for each plastic sheet. The different magnifications used were selected to cover the complete hole size distribution. Images of the sheets were processed by treating the holes as “bubbles” textural image analysis software, and reducing the images into a binary scale black (holes) and white (plastic) image. In this way, the holes were easily recognized and separated, when necessary, by comparing the image with the photos taken in the field before the retrieval. Processing was performed with the Matlab program FOAMS (Shea et al., 2010) to obtain the cumulative scoria size distributions (SSDs), based on area, and the total grain size distribution (TGSD). All the areas left by hot clasts were measured to reveal three distinct distributions; each partial curve represents different size ranges defined by the three different magnifications. If the distributions are plotted together, the curves overlap at two distinct points allowing two intersection values to be found. We worked on the curves defined between the two intersection limits, meaning that we avoided counting the same hole more than once. We thus choose the distribution obtained from the largest, median and smallest magnifications. These three “partial curves” were then merged to generate a unique scoria size distribution curve.
Once the plastic sheets were removed from the volcano summit area, those scoria that remained attached to their holes were measured and weighed. Measurements were made of the scoria major and minor axes, as well as that of the associated hole; and samples were weighted with a precision balance. Plotting the retrieved area and mass measurements revealed a linear relationship between hole area and mass, with a correlation coefficient (r2) of 0.94. This linear relationship is only valid for small fragments, having an area no greater

than 2000 mm^2. To generate a relationship for larger fragments, 53 bombs belonging to a more intense explosion that occurred at Stromboli on the 21 January 2010 were analyzed (data taken from Gurioli et al. 2013). Plotting their weights versus their areas, a similar relationship was found. Thus, the hole areas smaller than 2000 mm^2 were multiplied for 0.94, and the areas larger than 2000 mm^2 by 0.82, following the correlation coefficients found for two size classes. Results were then converted to weight percent (wt%), and the total deposit mass obtained by summing the three GSDs. Equivalent diameters (ϕ) were obtained and then converted to phi values (φ = -log2 ϕ). Thus, the TGSD across the ϕ = -9 to -3 interval (equivalent to ϕ of 512-8 mm) was obtained.

Field-derived grain size analyses



A new methodology allowed estimates of the volume and mass of a strombolian bomb field (Gurioli et al. 2013a). During June 2010 and June 2011 (6 and 18 months after a January 2010 eruption that emplaced the bombs) we mapped a bomb field extending SE to SW of Stromboli's Central Crater. Across our mapped area maximum surface slopes were 27-30°, however the bombs were all flattened on impact (being characterized by ellipsoid shape and all having similar thickness), and they stuck to the impacted surface without breaking, while preserving their pristine-landing shape and position. In total, 780 bombs were mapped. For each bomb we recorded handheld GPS location, and its long and intermediate axes (a and b, in mm). Scaled, vertical digital photos of 229 bombs were also manually taken. These were used to draw bomb perimeter and obtain "footprint" area using the SPO software of Launeau and Robin (1996). The area values obtained by the software were plotted against the area found by assuming an elliptical shape of all the bombs (equivalent ellipse) to look for a relation that could help in identifying the bomb areas for those without photos. The best fit between individual bomb area ($bomb_{area}$) and ab, was found to be $bomb_{area}$ = 0.7502(ab)0.9787, with an average error of 23 %; showing that the assumption of an elliptic shape was acceptable. Thus applying the correlation coefficient to all the sampled measures, all the areas were obtained.

We also derived a best fit between volume ($bomb_{volume}$) and ab based on an analysis of 53 bombs of known weight and density (average measured density: 1810 kg m^{-3}, ranging from 1370 to 2300 kg m^{-3}) sampled along the longitudinal and horizontal dispersal axis of the SSE-dispersion. The best fit of $bomb_{volume}$ = 0.2786(ab)1.3676 had an error of 25 %, much lower than the 150 % error that we obtained from estimating bomb volume by multiplying average bomb thickness (6.5 cm) by bomb area. Thus, we applied the best fit relation to derive the volume for all other bombs across the field. For the 53 sampled bombs, mass was measured directly in the laboratory. For all unsampled bombs, we calculated mass from multiplying volume by the average density. To allow comparison with sieving grain size analyses (Inman et al. 1952), we used the b axis dimension to obtain ϕ (= -log2b).