Explosive volcanic eruptions: from observations to quantification

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Eruptive styles can vary significantly based on several factors including magma composition, volatile content, magma feeding rate, tectonic setting and presence of external water. More than for the need to label volcanic eruptions, the importance of classification builds on the necessity of understanding volcanic processes through the identification and analysis of common features of eruptions having similar characteristics. Early classifications and terminology were mainly based on visual observations of eruptive phenomena at specific volcanoes and eventually evolved to take into account deposit features. In particular, Walker (1973, 1980) proposed a classification based on the analysis of tephra deposits and introduced five parameters for the estimation of the scale of explosive eruptions: i) magnitude, ii) intensity, iii) dispersive power (related to the total area of dispersal and, therefore, to plume height), iv) violence (related to kinetic energy), v) destructive potential. Even later classification schemes are based on parameters which are somehow related to these five kinds of bigness.

Out of all these parameters, the relation between magnitude and dispersive power (i.e., plume height) remains controversial. In fact, even though the Volcanic Explosivity Index (Newhall and Self, 1983) assumes a correlation between magnitude and intensity, the two parameters seem unrelated, especially for unsteady and effusive activity, with an eruption of small magnitude being able to have a high dispersive power if characterized by a high plume. This already highlights some of the shortcomings of current classification schemes that fail to well describe small to moderate explosive eruptions. In addition, many eruptions show hybrid features and could start with an eruptive style and terminate with a different activity resulting in a complex stratigraphic record difficult to classify. Finally, some small eruptions would be better described based on the analysis of all volcanic products and not only of tephra deposits (e.g. voume ratio between erupted lava and tephra).

Progress in physical volcanology and the increase capability of monitoring explosive eruptions have highlighted how a comprehensive classification should combine deposit features together with geophysical observations, with deposit features including deposit thinning, deposit grainsize, textural features, componentry, and both density and porosity of products. The development of a comprehensive classification scheme that can cover the whole range from weak explosions to ultraplinian eruptions presents one of the main challenges for the future. Regardless of the classification scheme considered, it is also very important to quantitatively characterize the uncertainty associated with the parameters used. The description of such uncertainty is crucial to any hazard assessment and evaluation of future eruptions at any given volcano.