From monitoring to forecasting
– Toward statistical evaluation of non-magmatic unrest –

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Phreatic eruptions are often referred to be exceptionally difficult to forecast by traditional geophysical techniques (de Moore et al., 2016). Although non-magmatic unrest phenomena can be hazardous in themselves, they are "too often overshadowed by eruption forecasting" (Rouwet et al., 2014). In many cases, volcanoes hosting a shallow hydrothermal system have background activities such as steaming ground, micro-seismicity, sporadic ground deformation, even during inter-eruptive periods, sometimes exhibiting states of non-eruptive and non-magmatic unrest. It is readily envisaged that such non-magmatic unrest events reflect a certain change in the shallow hydrothermal system. However, it is currently difficult to link them to the assessment of eruption imminence, or to the prediction of eruption intensity with a physical basis. On the other hand, given that an impermeable seal layer in a shallow hydrothermal system, or conduit obstruction due to deposition of alteration minerals can be important factors in the processes leading to a phreatic/hydrothermal eruption (e.g., Christenson *et al*., 2010; Tanaka *et al*., 2017, 2018; Stix and de Moor, 2018), monitoring such processes is a clue to evaluating the build-up phase of the eruption.

Here, some sort of statistical evaluation that is based on the monitoring records for the unrest events from multiple volcanoes of a similar type may be practically useful, instead of deterministic forecasting that generally requires the detailed information on the source parameter and the physical properties of the surrounding structure for a specific volcanos environment. Even if we do not have perfect knowledges on the detailed source geometry or location, ground deformation and the magnetic field changes, for example, can be indirect proxies of such processes, since they are considered to reflect pressure and/or temperature changes within a volcano. Hashimoto et al. (2019) provided one such example, where they collected information on reported non-magmatic unrest events mainly from Japanese volcanoes that have been monitored for extended time periods. They compiled the source depth, intensity, and the rate, based on the single magnetic dipole model or the Mogi model. Clear positive correlations were found between the source depth and its intensity and rate as a linear trend on the log-log scatter plots. Upward deviation from the linear trend on the scatter plot was found to be a potentially useful criterion, whereas the source depth by itself had no definitive relationship with the subsequent occurrence of eruptions. I consider that such an event collection can be the background data to predetermine the criteria of the Volcano Unrest Index (Potter et al., 2015), especially for "wet" volcanoes, as well as it can be optionally used to augment the VUIs functio n with a probabilistic evaluation.

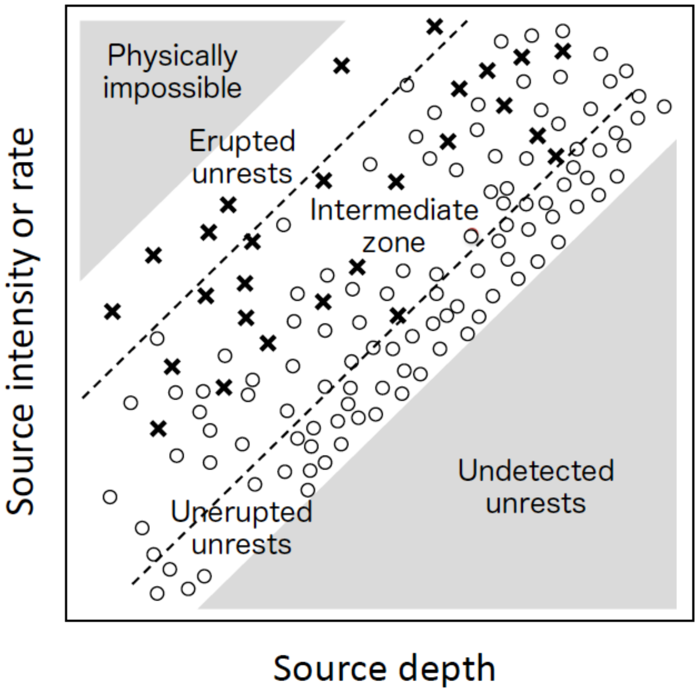

Fig. 1 Conceptual scatter plot demonstrating the statistical evaluation of non-magmatic unrest events (Hashimoto et al., 2019). The symbols × and ○ represent “erupted” and “unerupted” unrests, respectively. Both kinds occur in the intermediate zone between the two dashed lines. Very small events at great depths, which belong in the shaded triangular zone on the lower-right, are not observable (undetected unrests). Very strong events close to the ground surface, which belong in the shaded triangle on the upper left, are physically impossible.

Main References

Hashimoto T, Utsugi M, Ohkura T, et al (2019) On the source characteristics of demagnetization and ground deformation associated with non-magmatic activity. Bull. Volcanol. Soc. J., 64: doi: 10.18940/kazan.64.2_103

Potter S, Scott BJ, Jolly GE et al (2015) Introducing the volcanic unrest index (VUI): a tool to quantify and communicate the intensity of volcanic unrest. Bull. Volcanol., 77: doi: 10.1007/s00445-015-0957-4