From field data to volumes: constraining uncertainty for pyroclastic eruptions

Malin Klawonn[1], Bruce F Houghton[1], Donald A Swanson[2], Sarah A Fagents[1], Paul Wessel[1], Cecily J Wolfe[1]

[1]University of Hawaii, U.S.A., [2]Hawaiian Volcano Observatory, USGS, U.S.A.

E-mail: klawonn@hawaii.edu

In this study we aim to understand the variability in eruption volume estimates from field studies of pyroclastic deposits. Variability arises from three components: site selection in the field, hand-contouring of thickness measurements, and the selection of methods to integrate data and estimate volume. We distributed paper maps of the 1959 Kilauea Iki tephra dataset to 101 volcanologists worldwide, who produced hand-drawn contours. The returned isopach maps show great variety in contour number, spacing and shape. More experienced participants tended towards fewer, smoother, and more elliptical contours. However, these differences do not manifest in differences in isopach areas for a given thickness value. After excluding outliers we find that isopach area uncertainty lies around 7% across the well sampled deposit, but increases to over 30% for isopachs that are associated with the largest and smallest thickness measurements, where there is more uncertainty with the field data and hence more subjectivity. We fit exponential, power-law and Weibull functions through the isopach thickness versus square root area values and find an average standard deviation for total volume of s = 37%. The volume uncertainty is again largest (s = 58% to 59%) for the most proximal field that is not constrained by measurements and the distal field for which measurements are strongly affected by post-depositional processes, while uncertainty across the densely sampled deposit lies at s = 8%. In case of the Kilauea Iki 1959 eruption we find that the deposit beyond the 5 cm contour line contains only 1% of the total eruption volume, while the extrapolated near-source deposit contains 61% and the well-constrained intermediate deposit 38% of the total volume. Thus the relative uncertainty within each zone impacts total volume estimates differently. The large uncertainties in distal and proximal field are associated with the extrapolation of the empirical functions, and we expect uncertainty for different eruptions and eruption types to show similar uncertainty trends. Therefore, we suggest a new convention of stating all three partial volume estimates: one for the deposit that is constrained by measurements extending to the largest and smallest reasonable isopach, one for the extrapolated deposit above the thickest isopach and one for the extrapolated distal deposit beyond the thinnest contour. This convention allows third parties to better assess the associated uncertainty of an eruption volume, and is also a useful tool to identify desired measurement locations during a field campaign in order to improve the accuracy of volume estimate of a given deposit.