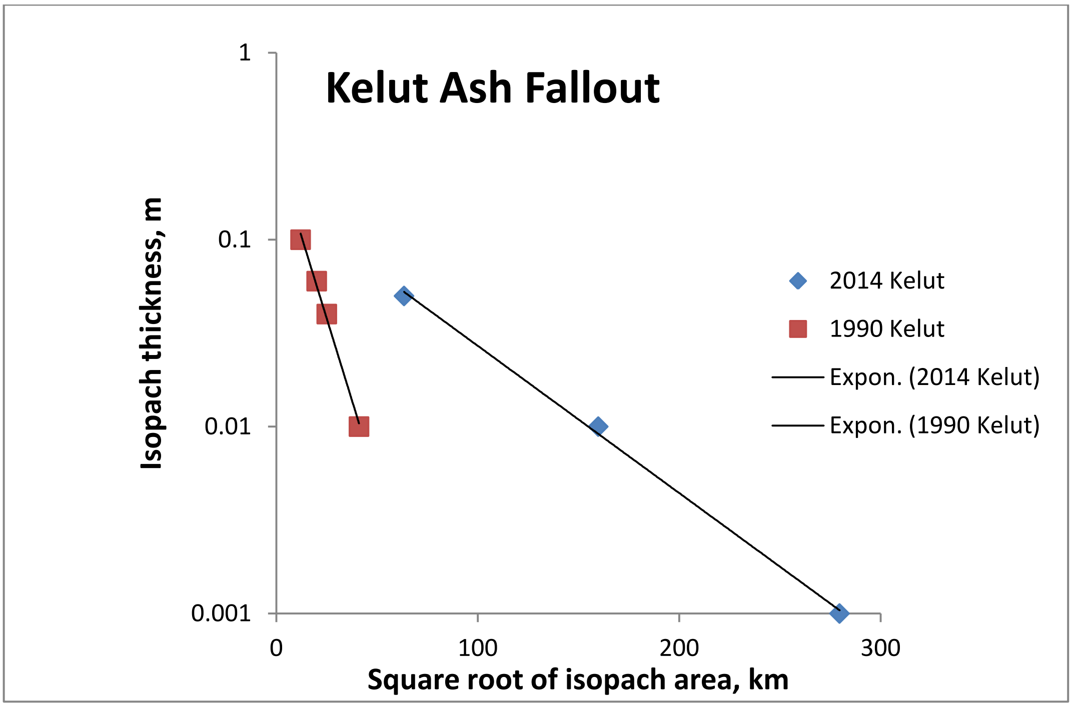
Ash fallout from the 2014 Kelut eruption: A Preliminary Analysis.

David Pyle and Oxford University's Earth Sciences Class of 2015. February 18, 2014.

Methods: as an exercise in a volcanology class, we searched for images from social media (Flickr, Instagram, Twitter) and from on-line photolibraries (Getty Images) that had been posted or uploaded following the eruption of Kelut. These were easy to find using obvious tags, including #Kelud or #Kelut for example. We located photographs, by either using images that were geotagged, or that identified a location in the caption of the photo, and classified the ash fallout very simply into three categories: 'light' (assumed to be ~ 1 mm); 'moderate' (assumed to be ~ 1 cm) and 'heavy' (assumed to be > 5 cm). From these data, we sketched up some very approximate isopachs (> 5 cm area is ~ 4000 km^2; 1 mm isopach area is ~ 80,000 km^2), and then plotted the isopach thickness data on a graph of log (thickness) – √(Area). The straight-line dependence of the data confirms that (to a first approximation) the thickness decays exponentially away from the source, and so we can use this to integrate and determine the deposited volume (Pyle, 1989). We have plotted up some of the 1990 isopach data as well, and it does appear that the 2014 eruption was indeed larger than the 1990 eruption.



Area – thickness plot for Kelut fall deposits. 1990 data from Bourdier et al., 1997 (not all proximal data are plotted).

Results: assuming exponential decay of the form $T = T_o\exp(-k\sqrt{A})$,the 2014 dataset falls along a trend with T_o = 0.17 m, k = 0.018 km^{-1}, and an erupted 'bulk ash' volume (= $2\,T_o/k^2$) of ~ 1 km^3. This seems quite large – but the bulk density of freshly deposited ash is likely to be around 500 - 800 kg/m^3; so this corresponds to a 'dense rock equivalent' volume of ~ 0.2 – 0.3 km^3, and an erupted mass of 5 – 8 x 10^{11} kg, or a **magnitude of 4.7 – 4.9**.

The estimated volume of the 1990 event was 0.12 km^3 (Bourdier et al., 1997; Thouret et al., 1998), based on field mapping after the event. If we assume that these deposits had compacted prior to mapping, and had a bulk density of 1000 – 1500 kgm^{-3} when mapped this would be equivalent to a deposit mass of 1.2 – 1.8 x 10^{11} kg., or a magnitude of 4.1 – 4.3.

Caveats: these observations are uncalibrated, and require confirmation from field measurement. If anything, they most likely provide an upper bound on the mass deposited; but they are consistent with the observed behaviour of the plume. Using Sparks et al's (1997) parameterisation of the relationship between plume height, H, and dense rock equivalent volumetric eruption rate of magma of $H = 1.67\ Q^{0.259}$, yields a mass eruption rate of $3x10^{7}$ kgs^{-1} - 10^{8} kgs^{-1} (for H ~ 19 – 26 km), and a total erupted mass of (3 – 10) $x10^{11}$ kg, assuming an eruption duration of 3 hours. This is a **magnitude of 4.5 – 5.0**, consistent with the fall out mass estimated above.

References:

Bourdier J-L, et al., 1997, Observations, stratigraphy and eruptive processes of the 1990 eruption of Kelut volcano, Indonesia Journal of Volcanology and Geothermal Research, 79, 181-203

Thouret, J-C et al., 1998, Origin characteristics and behaviour of lahars following the 1990 eruption of Kelud volcano, eastern Java (Indonesia), Bull Volcanol 59, 460-480.

Pyle, DM, 1989, The thickness, volume and grainsize of tephra fall deposits, Bulletin of Volcanology, 51, 1-15.

Sparks, RSJ et al (2007), Volcanic Plumes, Wiley.