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Abrasion during pyroclastic density currents

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During mass movements of any kind, particles interact with other particles. Rounded clasts in deposits from pyroclastic density currents (PDCs) have been observed repeatedly and are attributed to surface rounding (abrasion) or grain-size reduction (disruption) with following abrasion at the newly formed edges during clast collision. Transport-related processes of such kind will influence flow and sedimentation characteristics and grain size distribution in the deposits. Due to their heterogeneous composition in grain size and temperature (as well the velocities and energy involved), simulation of natural volcanic rock mass movements are generally not feasible in the laboratory. Here, rotational movement in a closed container was used as a proxy to shed light on the susceptibility of porous clasts to abrasion.
In this study, variously porous clasts of Unzen volcano (Japan) have been investigated ranging in open porosity from 5.7 to 53.5 vol.%. In different experimental runs, the starting grain size was homogeneous (-3.0 and -3.5 Phi, respectively) or heterogeneous (from -3.5 to 1.0 Phi). 40 to 160 g of the dry sample material were subject to rotational movement at ambient temperature in a rotational tumbler at constant speed. Experimental durations were 15, 30, 45, 60, and 120 minutes, respectively. The experimental durations employed are much longer than natural run-out times of volcanic mass movements, in order to help account for their highly energetic nature. Every experiment started with new sample material. The increase in generated fine particles (< 250 µm) was evaluated as a function of experimental duration and the open porosity of the samples.
The degree of abrasion was generally found to be slightly higher with coarser starting material size. The amount of generated particles is positively but non-linearly correlated with increasing porosity and is as high as 6 wt.%. Abrasion is highest for the longest experimental durations but a decreasing rate of efficiency is exhibited. Dense samples are slightly abraded and the increase in generated fine particles remained minor (< 1 wt.%) even in the 120 min experiments. Large phenocrysts were found to have represented zones of higher resistivity to abrasion.
It remains speculative, which of the performed experiments is closest to the natural scenario in PDCs. However, the results prove the dependency of abrasion on the physical properties of the sample. Increasing amounts of ash in volcanic currents influence flow and deposition behaviour by affecting effective runout distances and the mobility of the current. Consequently, knowledge of ash generation by abrasion is badly needed for adequate hazard assessment.