Abstract

During explosive volcanic eruptions, settling-driven gravitational instabilities can form at the base of the volcanic cloud. These result from the formation of an unstable particle boundary layer (PBL) which, upon reaching a critical thickness, can destabilize to generate fingers. These fingers can propagate downwards faster than the terminal settling velocity of fine ash, thus reducing the residence time of fine ash in the atmosphere. To reduce the risks associated with future eruptions, there is a need to better understand how this process governs the dispersion and sedimentation of tephra in order to refine models of deposition. This thesis seeks to improve the understanding of settling-driven gravitational instabilities through the means of analogue experiments that consider a buoyant particle suspension, representing the volcanic cloud, initially emplaced above a denser aqueous sugar solution, representing the underlying atmosphere. In particular, the effect of the lower layer density on the PBL and the physical characteristics of the fingers has been quantified. The results obtained show that the thickness of the PBL doesn't vary with the density, but that the critical PBL thickness is 1-2 orders of magnitude greater than previously predicted. They also demonstrate that the downward velocity of fingers are more than three times faster than the terminal settling velocity of individual particles. Future studies should continue to investigate the role of the density beneath the cloud, but consider a linear-stratification in the lower layer, reproducing the shape of the density profile seen in the atmosphere.

Keywords: *settling-driven gravitational instabilities, particle boundary layer (PBL), fingers, analog experiments with density variation*