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The muesli effect in pyroclastic density currents - what does reverse grading in an ignimbrite mean?

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Pyroclastic density currents (PDCs) are hot, density-driven flows of gas, rock and ash generated during explosive volcanic eruptions, or from the collapse of lava domes (e.g. Fisher, 1979; Branney and Kokelaar, 2002; Cas et al. 2011). They pose a catastrophic geological hazard and have caused >90 000 deaths since 1600AD (Auker et al. 2013). Improved understanding of PDCs will enable us to better understand the explosive eruptions that generate them, improving our preparedness for future volcanic events. However, these deadly hazards are rarely observed up close and are difficult to analyse in real-time. To understand the flow dynamics of density currents we must use models and interpretations of their deposits (e.g. Smith N and Kokelaar, 2013; Rowley et al. 2014, Williams et al. 2014, Sulpizio et al. 2014; Lube et al. 2019, Smith G 2018, 2020).

The deposits of pyroclastic density currents, known as 'ignimbrites' can reveal important clues about how these deadly volcanic hazards behave in time and space Reverse grading in an ignimbrite can be interpreted in different ways (Branney & Kokelaar, 2002). It could record a growing eruption intensity through time - where increasingly larger clasts are introduced into the pyroclastic density current. Alternatively, it could record Kinematic sorting (the 'muesli effect') and transport processes within the current where larger particles became increasingly likely to be deposited as the current wanes (Palladino & Valentine,1995). The link between current dynamics and reverse grading is currently untested in aerated granular currents.

This project seeks to investigate the relationship between current dynamics and deposit architecture, specifically by considering granular sorting mechanisms in unidirectional flow. We will use an analogue flume (following methods in Rowley et. al., 2014, and Smith G et al., 2018, 2020) to explore how reverse grading and lateral grading may be related to changes in grain sizes at source versus kinematic sorting processes. A mix of grain sizes will be incorporated into the current via a hopper which allows for the starting composition of the current to be varied e.g. homogenous mix versus layered. Photographs of the deposit will be taken through the transparent sidewall of the flume and analysed using image analysis software. These experiments will be complimented by static tests of kinematic sorting, where a Perspex column will be sliced to reveal internal 3d architecture. This project will contribute to our understanding of lithofacies architecture in the field, and help to quantity how we interpret the sedimentation of ignimbrites.

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