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Mapping the interaction of a pyroclastic density current with irregular topography: using compositional zoning as a proxy for time

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Pyroclastic density currents are known to have high mobility, overtopping topographic barriers great distances from source. However, how density currents interact with topography is not yet fully understood, particularly with regard to sustained currents, and energetic currents that are not confined to within valleys (e.g. those that deposit low aspect-ratio ignimbrites). Experiments indicate a variety of ways in which density-stratified pyroclastic density currents can interact with topography. They can overtop topographic barriers or partially overtop them by flow-stripping. Does the initial momentum of the current carry the leading edge over topographic barriers on initial encroachment, or does the mass flux have to increase above a certain threshold before the current is able to overtop the hill? Alternatively, the topography may have to be modified by deposit aggrading to the stoss side of the topographic barrier before a sustained density current can surmount the barrier. Can pyroclastic currents be reflected or deflected as seen in turbidity currents?

We used detailed chemical mapping to show how the response of an individual pyroclastic current to topographic barriers changed with time–the current first flowing around hills, and later (during peak flow) overtopping them. The pristine, welded Green Tuff ignimbrite (aspect ratio ∼1:3125) was deposited over irregular topography during the most recent (c. 46 ka) large explosive eruption on Pantelleria, Italy. The main (low aspect-ratio) ignimbrite flow-unit is gradationally zoned, systematically from pantellerite (base) to trachyte (top) and indicates that the composition of the pyroclastic density current gradually changed with time. Different geographic distributions of the individual compositional zones within the ignimbrite have enabled us to reconstruct a succession of snapshots of the current's evolution. The geographic 'footprint' of the current changed with time as the current gradually waxed and later waned. When the current initially encountered a hill or barrier, it was not able to overtop the hill. First it was blocked, reflected, or deflected around the lower flanks of barriers, including conical hills and transverse ridges. This is also recorded in imbricated clasts, and in rotated clasts in the more rheomorphic portions of the deposit. But as the current waxed, it progressively inundated, and then overtopped hills, during peak flow conditions. Later, as the current waned, it gradually retreated from summits, and once again became blocked or reflected by the hills. Such incrementally shifting responses of a pyroclastic density current to topography is consistent with shifting depositional patterns recorded in ignimbrites elsewhere (e.g. Poris ignimbrite, Tenerife). Such behaviour would probably be easily overlooked in ignimbrites that do not show compositional zoning but is to be expected wherever density currents are sustained and should probably be considered when assessing hazards at explosive volcanoes.