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Morpho-sedimentary responses to explosive volcanism: aftermath of the 22-23 April 2015 Calbuco eruption, southern Chile

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Landscapes impacted by explosive volcanism exhibit some of the highest sediment yields on Earth due to the overwhelming of ambient drainage and sedimentary systems by huge volumes of particulate material. While we have a first-order understanding of morpho-sedimentary responses in terms of patterns and chronologies of erosion, resedimentation, and aggradation, more recent studies have focused on untangling the system- and catchment-specific controls that govern the style, severity and duration of the post-eruptive impact.

An exemplar of this approach is afforded by the April 2015 eruption of Calbuco Volcano in southern Chile. This c. 0.31 km^3 event generated sub-Plinian eruption columns, multiple topographically confined pyroclastic density currents, and both hot and cold primary eruption-triggered lahars in multiple drainages. Fieldwork and remote-sensing analyses have focused on 3 major catchments with differing physiography and hydrological regimes that each received differing proportions and volumes of tephra and pyroclastic flow material.

Overall, except for where an internal impermeable crust is developing, the majority of the coarse tephra deposited by the 2015 eruption appears to have low remobilisation potential, suggesting that Calbuco lies close to the other end of the spectrum of post-volcanic landscape sensitivity to that shown by the 2008 Chaitén eruption. However, extensive pyroclastic flow deposits emplaced into proximal drainages have proved much more susceptible to remobilisation. In the most heavily impacted catchment, The Rio Blanco Este, which also lay under the tephra dispersal axis, major rain-triggered lahar activity was delayed until the first significant post-eruptive rainfall event in mid-May 2015. Up to 13 m of aggradation subsequently occurred downstream as material was remobilised from primary deposits and cannibalised from older ones. Estimated sediment yields peaked at c. 100,000 m^3/day in the first months post-eruption from an effective catchment area of c. 14.6 km^2, apparently declining exponentially since. Over the longer term, these proximal lahar deposits have themselves been incised and reworked, promoting further aggradation in medial reaches where historical lahar terraces are being overtopped. These patterns suggest that the pulse of volcaniclastic sediment is propagating distally as a kinematic wave, attenuating and dispersing with increased translation distance. Other catchments have behaved differently as a function of basin physiography, hydrology and the volumes and spatial distributions of pyroclastic material, although whether peak remobilisation has already occurred is contingent on the stability of a large reservoir of as yet untapped material identified high on the mountain.