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Causes, Dynamics and Impacts of Lahar Mass Flows due to the April 2015 Eruption of Calbuco Volcano, Chile

Alejandro Dussaillant (1,2,3), Andy Russell (1), Claudio Meier (4,2,5), Andres Rivera (6), Mauricio Mella (7), Natalia Garrido (7), Jorge Hernandez (6), Felipe Napoleoni (6), and Cristian Gonzalez (5)

(1) University of Newcastle, Newcastle, United Kingdom, (2) Centro de Investigaciones en Ecosistemas de la Patagonia, Coyhaique, Chile, (3) VAFT Ltd., London, United Kingdom, (4) University of Memphis, Memphis, USA, (5) Universidad de Concepcion, Concepcion, Chile, (6) CECS-Center for Scientific Studies, Valdivia, Chile, (7) SERNAGEOMIN National Geology and Mining Service, Puerto Varas, Chile

Calbuco is a 2015m high, glacier capped, stratovolcano in the heavily populated Los Lagos region of southern Chile with a history of large volcanic eruptions in 1893–95, 1906–7, 1911–12, 1917, 1932, 1945, 1961 and 1972. Calbuco volcano experienced a powerful 90 minute eruption at 18:04h on 22 April, 2015 followed by additional major eruptions at 01:00h and 13:10h on 23 & 30 April, respectively, resulting in the evacuation of 6500 people and the imposition of a 20 km radius exclusion zone. Pyroclastic flows descended into several river catchments radiating from the volcano with lahars travelling distances of up to 14 km, reaching populated areas. We present findings from detailed field observations from April and July 2015, and January 2016, regarding the causes, dynamics and impacts of lahars generated by the April 2015 eruption, supported by satellite imagery, LiDAR and detailed rtkGPS & TLS surveys, as well as sediment sampling. Pyroclastic flows melted glacier ice and snow generating the largest lahars in the Rio Este and Rio Blanco Sur on the southern flanks of the volcano. Lahar deposits in the Rio Blanco Norte were buried by pyroclastic flow deposits with measured temperatures of up to 282°C three months after emplacement. Lahar erosional impacts included bedrock erosion, alluvial channel incision, erosion of surficial deposits and the felling of large areas of forest. Depositional landforms included boulder run-ups on the outsides of channel bends, boulder clusters and large woody debris jams. Lahars deposited up to 8m of sediment within distal reaches. Deposits on the southern flanks of Calbuco indicate the passage of multiple pulses of contrasting rheology. Lahar occurrence and magnitude was controlled by the pre-eruption distribution of snow and ice on the volcano. Pre-existing lahar channels controlled flows to lower piedmont zones where routing was determined by palaeo-lahar geomorphology. Ongoing erosion of proximal pyroclastic flow and lahar deposits provides large volumes of sediment to distal portions of fluvial systems radiating from Calbuco, continuing impact on infrastructure and settlements, including secondary lahars due to rain and melt events. The database generated by this study hopes to contribute to further studies into lahars, including its use to test lahar numerical models.