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'Understanding volcanoes and society: the key for risk mitigation'

Hydrogeomorphic response to explosive eruptions--a significant, yet underappreciated, volcano hazard

Jon J. Major[1], Thomas C. Pierson[1], Álvaro Amigo[2], Daniel Bertin[2], Hugo Moreno[2], Andrés Iroumé[3], Héctor Ulloa[3]

[1]U.S. Geological Survey, Cascades Volcano Observatory, Vancouver, Washington, USA

[2]Servicio Nacional de Geología y Minería, Programa de Riesgos Volcánicos, Temuco, CHILE

[3]Faculty of Forest Sciences and Natural Resources, Universidad Austral de Chile, Valdivia, CHILE

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Hazards assessments at explosive volcanoes commonly focus on primary phenomena such as debris avalanches, pyroclastic density currents, lahars, and airfall tephra. Although primary processes can be devastating and far reaching, secondary hydrologic and geomorphic (hydrogeomorphic) processes to eruptions—such as flooding; sediment redistribution; and channel aggradation and migration—can have equal or greater consequences. Hydrogeomorphic responses to eruptions can persist years to decades, and can impact downstream communities not affected directly by an eruption. Yet, secondary processes commonly are underappreciated when assessing volcano hazards. The 2008–09 eruption of Chaitén volcano, Chile, highlights important aspects of hydrogeomorphic responses to explosive eruptions. The eruption's 10-day explosive phase draped adjacent watersheds with centimeters to >1 m of tephra. Lava-dome-collapse pyroclastic flows delivered additional channel sediment. During waning explosive activity, modest rainfall (a few tens of mm) triggered extraordinary sediment delivery that swiftly aggraded several channels by many meters. Ten km from the volcano, Chaitén River channel aggraded 7 m (5 m in 24 hours) and the river avulsed through coastal Chaitén town. Sediment buried much of the town to 3-m depth. Though a dilute lahar caused substantial channel aggradation, a sediment-laden water flood caused direct damage to the town. Within weeks, the channel incised; it remains laterally unstable. By late 2011, abnormal sediment delivery amassed about 11 million m3 of sediment in a delta at the mouth of the new channel. That delta disrupted local commerce and encroached on a ferry dock, threatening a major regional transportation link. Stratigraphy along Chaitén River valley reveals extensive similar fluvial deposits from past eruptions. Hydrogeomorphic response to this eruption emphasizes two key, but underappreciated concepts: 1) hazardous mobilization of sediment can be triggered by modest rainfall; and 2) deleterious lahar–floods can occur swiftly after rainfall on fresh tephra begins, perhaps before vulnerable communities can be warned or evacuated.