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Tectonics control over instability of volcanic edifices in transtensional tectonic regimes

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We present the results of analogue modeling designed to investigate the interactions between volcanic edifices and transtensional basement faulting. Three sets of experiments were run to account for three examples of stratovolcanoes in active transtensive tectonics regimes, the Nevado de Toluca and Jocotitlan volcanoes in Mexico, and the Mayon volcano in the Philippines. All these volcanoes show different behavior and relationship among volcanism, instability of the volcanic edifice, and basement tectonics. Field geological and structural data gave the necessary constrains to the models. The modeling apparatus consisted of a sand cone on a sheared basal layer. Injections of vegetable oil were used to model the rising of magma inside the deformed analogue cones.
Set 1: In the case of a volcano directly on top of a basal transtensive shear producing a narrow graben, as observed on the Nevado de Toluca volcano, the analogue models reveal a strong control of the basement faulting on the magma migration path and the volcano instability. Small lateral collapses are directed parallel to the basal shear and affect a limited sector of the cone.
Set 2: If the graben generated by transtensive tectonics is bigger in respect to the volcanic edifice and the volcano sits on one boundary fault, as in the case of Mayon volcano, the combined normal and transcurrent movements of the analogue basement fault generate a sigmoidal structure in the sand cone, inducing major sector collapses directed at approx 45° relative to the basement shear toward the downthrown block.
Set 3: For volcanoes located near major transtensive faults, as the Jocotitlan volcano, analogue modelling shows an important control of the regional tectonics on the geometry of the fractures and migration paths of magma inside the cone. These structures render unstable the flanks of the volcano and promote sector collapses perpendicular to the basement shear and directed toward the graben formed by the transtensive tectonics.
Direction and volume of sector collapses greatly varies in respect to the geometry and kinematics of the basal shear, from parallel to perpendicular to the basement fault, and from small localized gravitational failures to major sector collapses. From the hazard perspective, our work provides new basis for the evaluation of sector collapse potential of volcanoes that undergone transtensional tectonics.