



Imaging the 2013 explosive crater excavation and new dome formation at Volcán de Colima with TerraSAR-X, time-lapse cameras and modelling

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The summit region of steep volcanoes hosting lava domes often displays rapid geomorphologic and structural changes, which are important for monitoring the source region of hazards. Explosive crater excavation is often followed by new lava-dome growth, which is one of the most dynamic morphometric changes that may occur at volcanoes. However, details of these crater formations, and the ensuing new dome growth remain poorly studied. A common problem is the lack of observational data due to hazardous field access and the limited resolution of satellite remote sensing techniques. This paper describes the destructive-constructive crater activity at Volcán de Colima, Mexico, which occurred between January and March 2013. The crater geometry and early dome formation were observed through a combination of high-resolution TerraSAR-X spotmode satellite radar images and permanently installed monitoring cameras. This combined time-lapse imagery was used to identify ring-shaped gas emissions prior to the explosion and to distinguish between the sequential explosion and crater excavation stages, which were followed by dome growth. Crater formation and dome growth is first observed by the TerraSAR-X data. By means of particle image velocimetry, the digital flow field is computed from consecutive camera images, showing that vertical dome growth is dominant at the beginning. The upward growth is found to grade into spreading and a lateral growth domain. After approximately two months of gradually filling the excavated craters with new magma, the dome overflows the western margin of the crater and develops into a flow that produces block and ash flow hazards. We discuss and compare the observations to discrete element models, allowing us to mimic the vertical and lateral growth history of the dome and to estimate the maximum strength of the bulk rock mass. Moreover, our results allow a discussion on the controls of a critical dome height that may be reached prior to its gravitational spreading. This study, for the first time, provides a detailed view into explosive crater formation and new dome formation at Volcán de Colima, with important implications for other dome-building volcanoes.