Master in Earth Sciences

by

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Landslide and structural analysis of an unresting volcano using drone imagery and field observations at Askja caldera (Central Iceland).

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Abstract

Large volcanoes are often prone to flank instabilities and structural failures. Faulting, dike intrusion, rock alteration, weathering and seismicity are some of the factors that contribute to catastrophic landslides and eruptions. Due to the complexity of these interacting factors, volcano instabilities are still poorly understood. Here we study the influence of volcanic caldera's structural geology on the potential for flank failure in volcanic edifices. Here we study the structural geology of a large volcano and its relation to flank instabilitiesinstability.

This study focused on the Öskjuvatn caldera, which is one of the three calderas of the Askja central volcano in Central Iceland. Askja is an active volcano, currently in unrest since 2021, with intense hydrothermal activity, ground deformation and constant seismic activity. The Öskjuvatn caldera witnessed one of the largest landslides in the Iceland's history in 2014 and is the site of continuous mass movements.

Our objective is to map and analyze fractures and other structures to understand their origin and their influence, in structurally-controlled slope instabilities. We used high-resolution (~4cm/pixel) orthophotos and DEM captured with a fixed-wing drone on the eastern portion of the Öskjuvatn caldera to analyze and map different volcanic, tectonic, and gravitational structures that influence the slope stability. We also use computational 3D models and collected geological data in the field to comprehend the nature of fractures in three dimensions.

Our results show a predominance of fracture clusters related to the caldera structure and secondary fractures associated to the North Volcanic Zone (NVZ). The vertical nature of these fractures and the presence of downsag structures highlight the dominance and influence of the central volcano stress field. As for the landslide analysis, we found an specific interaction between the different sets of fractures. This contributes to the focalized gravitational activity in the southeast of the caldera, which seems to be enhanced by the concentration of hydrothermal activity. However, several structures and processes were identified and analyzed to encompass the overall current structural condition of the slope.

This detailed study, combining different methodologies, aims to contribute to the current knowledge of the Öskjuvatn caldera and its interaction with the NVZ. Also, it means to be a valuable initial step for future studies related to complex flank instabilities in Askja and at other large volcanoes worldwide.

Keywords: Öskjuvatn caldera, Askja, structural geology, flank instability, fracture analysis, kinematic analysis.