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Insights into the kinematics of a volcanic caldera drop: Probabilistic finite-source inversion of the 1996 Bardarbunga, Iceland, earthquake

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The accurate modelling and prediction of volcanic eruptions depends critically on information concerning the interaction between the caldera and the underlying magma chamber. Knowledge concerning the kinematics of a caldera in the course of an eruption is therefore essential.

Here we provide detailed seismological constraints on the kinematics of a volcanic caldera drop and the geometry of a caldera ring fault. For this we performed a finite-source inversion of the September 29, 1996 Bardarbunga, Iceland, earthquake that was caused by caldera subsidence. Our methodology is based on spectral element simulations of seismic wave propagation through a realistic model of the Icelandic crust and upper mantle.

A particularly robust feature is the initiation of the rupture in the north-western part of the ring fault that is about 10 km in diameter. From there it spread to the other fault segments within about 3 s. Without invoking super-shear propagation sensu stricto, we can explain this unusually fast rupture propagation by the triggering of fault segments through P waves that propagated across the caldera. Our results favour outward-dipping fault segments in the western half of the ring fault, while the eastern half is preferentially inward-dipping. This variability may reflect structural heterogeneities or an irregular magma chamber geometry. The individual segments of the caldera ring fault radiated approximately equal amounts of energy. This indicates that the caldera dropped coherently as one single block.

The work presented here is intended to aid in the design of realistic models of magma chamber and caldera dynamics.