Geophysical Research Abstracts
Vol. 15, EGU2013-7104, 2013
EGU General Assembly 2013

Characterizing analogue caldera collapse with computerized X-ray micro-tomography

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Analogue models in the past mainly explored caldera collapse structures by documenting 2D model cross-sections. Kinematic aspects and 3D structures of caldera collapse are less well understood, although they are essential to interpret recent field and monitoring data. We applied high resolution radiography and computerized X-ray micro-tomography (μCT) to image the deformation during analogue fluid withdrawal in small-scale caldera collapse models. The models test and highlight the possibilities and limitations of μCT-scanning to qualitatively image and quantitatively analyse deformation of analogue volcano-tectonic experiments. High resolution interval radiography sequences document '2.5D' surface and internal model geometry, and subsidence kinematics of a collapsing caldera block into an emptying fluid body in an unprecedented way. During the whole drainage process, all subsidence was bound by caldera ring faults. Subsidence was associated with dilatation of the analogue granular material within the collapsing column. The temporal subsidence rate pattern within the subsiding volume comprised three phases: 1) Upward ring fault propagation, 2) Rapid subsidence with the highest subsidence rates within the uppermost subsiding volume, 3) Relatively slower subsidence rates over the whole column with intermittent subsidence rate acceleration. Such acceleration did almost never affect the whole column. By using radiography sequences it is possible in a non-destructive manner to obtain a continuous observation of fault propagation, down sag mechanisms and the subsequent development of collapse structures. Multi-angle μCT scans of the collapse result allow for a full virtual 3D reconstruction of the model. This leads to an unprecedented 3D view on fault geometries. The developed method is a step towards the quantitative documentation of volcano-tectonic models that would render data interpretations immediately comparable to monitoring data available from recent deformation at natural volcanoes. The models carry the potential for a better understanding of the kinematics of caldera collapse amongst a variety of volcano-tectonic processes.