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A multidisciplinary approach to unravel hydrothermal explosions: a case-study from Gengissig lake (Kverkfjöll volcano, Iceland)

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On August 15, 2013, a small jökulhlaup occurred when the Gengissig ice-dammed lake drained at Kverkfjöll, a central volcano with an active geothermal area located at the northern edge of Vatnajökull. The lake level dropped by approximately 30 m, decreasing pressure on the lake bed and triggering several steam-driven explosions.
The explosions involved the surficial part of a hydrothermally altered glacio-lacustrine deposit mainly composed of pyroclasts, lava fragments and volcanic bombs, interbedded with clay-rich layers. Small fans of ejecta were formed, reaching a distance of 1 km north of the lake covering an area of approximately 0.3 km2, with a maximum thickness of 40 cm at the crater walls.
The explosions, triggered by the rapid boiling in the surficial geothermal reservoir which followed the abrupt decrease in confining pressure, ejected approximately 10ˆ4 mˆ3 of mostly loose material. The thermal and cratering energy, calculated for the explosion areas, are on the order of 10ˆ11 and 10ˆ10J, respectively. Comparison of the calculated energies with those estimated by the volume of the ejecta and the crater sizes, yields a good agreement between models and field data.
Morphological analyses (SEM) were used for a qualitative estimation of amount of freshly-fragmented clasts in the ejected material revealing that a low but significant energy consumption by fragmentation occurred.
Decompression experiments were performed in the lab mimicking the conditions due to the drainage of the lake. A large amount of fine material was produced in these experiments possibly indicating active fragmentation. Furthermore, ejection velocities of the particles of 40-50 m/s, measured via high-speed videos, are consistent with those estimated from the field.
This study demonstrates how the effective combination of field and lab data together with theoretical modeling can provide robust constraints on energy release and partitioning for such low-magnitude yet hazardous, steam-explosion events.