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Analogue modelling of the rupture process of vulnerable stalagmites in an earthquake simulator

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Earthquakes hit urban centers in Europe infrequently, but occasionally with disastrous effects. Obtaining an unbiased view of seismic hazard is therefore very important.

In principle, the best way to test Probabilistic Seismic Hazard Assessments (PSHA) is to compare them with observations that are entirely independent of the procedure used to produce PSHA models. Arguably, the most valuable information in this context should be information on long-term hazard, namely maximum intensities (or magnitudes) occurring over time intervals that are at least as long as a seismic cycle.

Long-term information can in principle be gained from intact and vulnerable stalagmites in natural caves. These formations survived all earthquakes that have occurred, over thousands of years - depending on the age of the stalagmite. Their "survival" requires that the horizontal ground acceleration has never exceeded a certain critical value within that time period.

To determine this critical value for the horizontal ground acceleration more precisely we need to understand the failure process of these intact and vulnerable stalagmites. More detailed information of the vulnerable stalagmites' rupture is required, and we have to know how much it depends on the shape and the substance of the investigated stalagmite.

Predicting stalagmite failure limits using numerical modelling is faced with a number of approximations, e.g. from generating a manageable digital model. Thus it seemed reasonable to investigate the problem by analogue modelling as well.

The advantage of analogue modelling among other things is that nearly real circumstances can be produced by simple and quick laboratory methods.

The model sample bodies were made from different types of concrete and were cut out from real broken stalagmites originated from the investigated caves. These bodies were reduced-scaled with similar shape as the original, investigated stalagmites. During the measurements we could change both the shape and the material and the time series of acting horizontal acceleration. Comparing the results from analogue to numerical modelling could improve the accuracy of long-term seismic hazard assessment.