



Constraints on Long-Term Seismic Hazard From Vulnerable Stalagmites for the surroundings of Katerloch cave, Austria

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Earthquakes hit urban centers in Europe infrequently, but occasionally with disastrous effects. This raises the important issue for society, how to react to the natural hazard: potential damages are huge, and infrastructure costs for addressing these hazards are huge as well. Obtaining an unbiased view of seismic hazard (and risk) is very important therefore.

In principle, the best way to test Probabilistic Seismic Hazard Assessments (PSHA) is to compare with observations that are entirely independent of the procedure used to produce the 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. Such information would be very valuable, even if it concerned only a single site.

Long-term information can in principle be gained from intact stalagmites in natural karstic caves. These have 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 period.

We are focusing here on a case study from the Katerloch cave close to the city of Graz, Austria.

A specially-shaped (candle stick style: high, slim, and more or less cylindrical form) intact and vulnerable stalagmites (IVSTM) in the Katerloch cave has been examined in 2013 and 2014. This IVSTM is suitable for estimating the upper limit for horizontal peak ground acceleration generated by pre-historic earthquakes. For this cave, we have extensive information about ages (e.g., Boch et al., 2006, 2010).

The approach, used in our study, yields significant new constraints on seismic hazard, as the intactness of the stalagmites suggests that tectonic structures close to Katerloch cave, i.p. the Mur-Mürz fault did not generate very strong paleoearthquakes in the last few thousand years. This study is particular important for understanding the seismic hazard associated with the town of Graz.

The acceleration level determined by our study for the territory of Katerloch cave is much lower than the PGA value interval (from 0.075 g to 0.1 g, in case of arithmetic mean, 85% fragile, rock type) determined by probabilistic seismic hazard calculation (SHARE Model, e.g., Giardini et al., 2013,) for a 475 years recurrence time (in 50 years with 10% probability of exceedance).