Geophysical Research Abstracts
Vol. 20, EGU2018-12884, 2018
EGU General Assembly 2018

Modeling depth-dependent attenuation using real in-situ velocity data, improvements of former stalagmite study for determining critical horizontal ground acceleration

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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. The best way to test Probabilistic Seismic Hazard Assessments (PSHA) is probably to compare them with observations that are independent of the procedure used to produce PSHA models. Such information can in principle be gained from intact and vulnerable stalagmites in natural caves. In addition, these constraints concern long time scales for which observational constraints are usually very rare. 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. A question in this regard is though how to relate that critical value (within the cave) with peak ground accelerations or intensities that relate to Earth's surface where man-made structures are placed.

In a previous study we have focused on a case study from the Detrekői zsomboly cave (Plavecka priepast'), Little Carpathians, Slovakia. The approach yielded significant new constraints on seismic hazard, as the intactness of the stalagmite suggests that tectonic structures close to the cave, e.g. the Vienna basin and the Mur-Mürz fault did not generate very strong paleoearthquakes in the last few thousand years.

In order to determine the critical horizontal ground acceleration value correctly it is necessary to know the depth-dependent attenuation of seismic waves. The most natural solution of this problem would be to measure the horizontal ground acceleration in-situ by installing seismic stations at the surface and in the cave simultaneously, and by comparing the two time series. So far we have not had the possibility to measure ground acceleration in-situ, we therefore determine the attenuation by seismic modeling. Here, we present these model computations.

The 1D velocity model of the rock above the cave is one of the input parameters for the model computations. In order to prepare the most appropriate 1D velocity model, active shallow seismic measurements have been performed at different locations above the Detrekői cave at the surface. Two kinds of model computations have then been performed. In the first case the selected earthquakes have similar parameters as the Jókő (Dobra Voda) event that has occurred in 1906, while at the second case the earthquakes were similar to the one which has been argued to have occurred on the Lasse fault around 350 AD, and destroyed the Roman legionary camp, Carnuntum.