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Estimation of an upper limit on prehistoric horizontal peak ground acceleration using the parameters of intact stalagmites and the mechanical properties of broken stalagmites in Domica cave, Slovakia

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The examination of special shaped, vulnerable, intact stalagmites in Domica cave (Slovakia) is the continuation of our previous examination of speleothems in Baradla cave (north eastern Hungary). (The Domica and Baradla caves really are two different parts of the same cave system.) The aim of our investigation is to estimate the upper limit for horizontal peak ground acceleration generated by paleoearthquake.

There are many vulnerable, special shaped (high, slim and more or less cylindriform) stalagmites in Domica cave. The most vulnerable of these stalagmites have 5 m height and 6 or less than 6 cm diameter at the profile of cylinder, which we have found in Devil's Hall of Domica cave..

The method of our investigation is the same as before: the density, the Young's modulus and the tensile failure stress of the samples originating from broken stalagmites (lying on the ground of Domica cave) have been measured in mechanical laboratory, whereas the natural frequency of intact stalagmite was determined by in situ observation. The value of horizontal ground acceleration resulting in failure and the natural frequency of stalagmite were assessed by theoretical calculations.

Our results show, that the tensile failure stress of the samples originating from Devil's Hall of Domica cave higher, than the tensile failure stress of the samples originating from Olimposz Hall of Baradla cave, however the value of Young-modulus is lower.

The age of the samples taken from a stalagmite standing in Domica cave have been determined by inductively coupled plasma mass spectrometry analysis (MC-ICPMS). Our measurements show that this stalagmite is still growing and the oldest and bottommost part of it is not older than 117 000 years. The age of the oldest part of stalagmite in Domica nearly the same (130 000 years) as the 5.1 m high stalagmite situated in Olimposz Hall of Baradla cave.

The ag value (upper limit for horizontal peak ground acceleration) coming from theoretical calculation is almost the same (0.06g) as it is in the case of stalagmite in Olimposz Hall. On the grounds of our measurements and theoretical calculations, we can state that the geological structures close to Baradla and Domica caves did not excite such paleoearthquakes in the last thousand years, which would have produced horizontal ground acceleration larger than 0.06g
This value can arise even in case of moderate sized earthquakes. The natural frequency of this stalagmite –situated in Devil's Hall– is low, about 1 Hz. Since this low value is in the frequency range of nearby earthquakes, therefore resonance effect can occur. Because of the resonance the failure acceleration can be even smaller.