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New data from the Nerja Cave, Southern Spain - geophysics, borehole camera and CO2 measurements for karst investigations

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The Nerja Cave in Southern Spain is listed as UNESCO Cultural Heritage and counts as one of the most popular touristic sites on the Iberian Peninsula. The cave reaches several hundreds of meters into the dolomitized marble and hosts paleolithic and post-paleolithic wall paintings as well as countless spelaeothems.
During the last decades, systematic CO2 measurements were conducted inside the galleries in order to monitor the gas concentration. Nearby drill holes with depths of up to 400 m were also probed. Here, CO2 concentrations of up to 55000 ppm were measured regularly. These values are much higher than the average and far beyond the concentrations inside the cave (525 ppmv). If cavities in the surroundings of the drill holes would be connected to the Nerja Cave system via the karstified marbles, the heritage site would not only have to be closed for the public, but would also suffer damages due to solution by H2CO3.
We applied georadar (GPR), capacitive coupled resistivity (CCR) and a borehole camera in order to identify cavities in the surroundings of the cave. The camera can reach depths of up to 100 m, is equipped with LEDs, and produces colour images with a pivoting lens system. We found formerly unknown cavities with diameters of several metres in some cases, most of them in depths of 6 to 13 metres. Spelaeothems were present in some cavities. GPR (100 MHz system) could prove these findings and trace the cavities between the drill holes. Hereby, the compact marbles feature good wave propagation conditions and the cavities yield strong reflections. Since the maximum resolution of the GPR system is in the order of 0.3 m, smaller hollows must necessarily remain undiscovered.
The mobile CCR system (OhmMapper) represents a relatively new technique that is not commonly used for karst investigations. As hard rocks crop out at the surface of the study site, classical geoelectrics with steel electrodes stuck into the ground could not be used or would have required additional drillings in the nature reserve area. Hence, the CCR system was applied despite its low resolution and limited penetration depths. The data show good coherence with GPR and optical imaging results, and it is possible to detect bigger cavities reliably as high-resistivity anomalies.
We could determine several cavities with extraordinary high CO2 contents in the surroundings of the cave, but found no hints for a direct and highly permeable connection to the heritage site. Furthermore, it was possible to verify the results with shallow geophysics and to establish a new technique in karst research.