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Laser scanning and 3D printing of Ca' Castellina cave ceiling (North Italy): a novel approach to visualize and better understand antigravitative morphologies

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Cave exploration is feasible by only a minimal number of well-trained geologists. However, underground environments can be considered as excellent natural laboratories for the study of multiple disciplines among the Earth Sciences, such as geomorphology, minero-petrography, geochemistry, palaeoclimate, tectonics, meteorology, geomicrobiology, seismology, archaeology and palaeoanthropology, etc. Thus, a good presentation of cave data is vital to shed light to this dark but scientifically precious environment.
Terrestrial laser scanning (TLS) has increasingly been used to survey subterraneous environments, allowing the creation of 3D high-resolution cave maps (Fabbri et al., 2017). Furthermore, TLS can be used to study underground morphologies in detail; the resulting point cloud is post-processed into three-dimensional digital model, where volumes and surfaces can be calculated with millimetric precision, thus permitting a rigid comprehension of the genesis and evolution of the studied shapes. Additionally, the obtained 3D model can be easily printed, creating an on scale plastic cast and resulting in a novel way to represent cave features. These miniaturised models can then be used to study water flow in the laboratory.
We focus TLS and 3D printing to the ceiling of Ca' Castellina cave (Emilia Romagna, North Italy). The cave, carved in Messinian gypsum beds (De Waele et al., 2017), presents a network of antigravitative ceiling channels and pendants (Pasini, 2009) rarely visible elsewhere in such a complexity and interconnection. These morphologies are a rare example of antigravitative erosion connected to local base level aggradation (i.e. surface river), formed when cave infillings (i.e. sediments) force underground waters to carve gradually upward, at some point triggering the antigravitative erosion of the roof (Pasini, 2009) in epiphreatic (or phreatic) conditions. Our high-resolution survey identified three generations of channels otherwise difficult to identify at naked eye. Because their formation is ultimately controlled by climate (base level variation, sediment availability, underground water circulation, etc) (Columbu et al., 2015), this study brings evidences of pulse-like climate variations affecting underground cave morphology in Northern Italy.
This is a double-aim study: 1) understand the climate-driven peculiar ceiling morphology characterizing Ca' Castellina cave; and 2) make underground morphologies physically visible for all geoscientists.

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