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Geomorphological maps and 3d models in cave research

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Cave geomorphological processes and features can be studied by geomorphological maps although topographic maps, aerial photos and GPS are not available. Methods in cave geomorphological mapping are conditioned by cave environment configuration, the need of using speleological techniques, and limitations arising from the projection of the 3D data from the cave to a 2D plan. Some of our previous works in the Cantabrian Mountains and Cantabrian Coast (NW Spain) established the approach of the design of cave geomorphological maps and its legend. Today we are improving the display of cave process combining geomorphological maps and 3d models based on the experience obtained from the research of one cave from the Cantabrian Coast and four caves in the Picos de Europa National Park (funded by GEOCAVE project, Spanish National Parks Agency). The five caves are developed in Carboniferous limestone affected by faults and thrusts. The method of work includes: 1) the elaboration of the cave survey at 1:50 to 1:500 scale; 2) the check of the cave survey of three caves by closed loops; 3) the mapping of cave features based on the performed survey; 4) the 3d modeling of the caves approximating each survey shoot by an octagonal prism; and 5) the implementation and management of the survey and geomorphological map in a Geographic Information System. Based on the survey, the cavities are small caves to deep alpine shafts with 281 to 4,438 m length and up to 738 m deep. The precision of the cave maps only could be estimated in two caves at a cavity scale, displaying both of them a 2.49 % error. The prisms of the 3d model was classified into four groups according to the morphology of the cave passage: 1) canyons, 2) phreatic and epiphreatic tubes, 3) soutirage conduits, 4) mixed forms composed by phreatic and epiphreatic tubes modified by fluvial incision, 5) pitches and 6) irregular passages enlarged strongly by gravity process. According to our previous works geomorphological features were classified using genetic and morphological criteria in four groups: 1) fluviokarst features; 2) speleothems; 3) gravity forms; and 4) anthropogenic features. Canyons passages usually include vadose erosive forms and few dripstones and flowstones; the phreatic and epiphreatic tubes frequently display many phreatic erosive features, fluvial and torrential deposits, flowstone, dripstone and few and small breakdown deposits; the soutirage conduits shows phreatic erosive features and few dripstone and gravity deposit removed from upper passages; the mixed forms combine the features of canyons and phreatic and epiphreatic tubes detailed above; the pitches display small dripstone and flowstone in the walls and gravity deposits or vadose erosive forms in its bottom; and the passages enlarged strongly by gravity process contain big talus deposits and some small slides that modified previous fluviokarst and speleothems features. Consequently, the results evidence that the geometry and geomorphology of the cavities can be defined together combining the geomorphological maps and 3d model in order to link the morphology of the conduits with the cave processes.