



Quantitatively structural control of the karst based on speleological cave survey data: Cabeza Llerosos massif (Picos de Europa, Spain)

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Speleological cave survey characterizes each cave passage by a 3D line (called shot survey) defined by its length, direction and dipping. This line represents the three-dimensional geometry of the karst system and cave passage scale and can be statistically analyzed and compared with the geometry of the massif discontinuities. The aim of this work is to establish the quantitative influence of the structural geology in caves based on the comparison between cave survey data, joint and bedding measurements with stereographic projection. 15 km of cave surveys from Cabeza Llerosos massif (Picos de Europa, Northern Spain) were chosen to illustrate the method. The length of the cavities range between 50 to 4,438 m and their depth is up to 738 m. The methodology of work includes: 1) cave survey collection from caving reports; 2) geological mapping and cross-sections with cavities projection; 3) data collection of bedding and joints in caves and near outcrops; 4) definition of families of joints and bedding planes by stereographic projection; 5) definition of groups of cave passages from stereographic projection (based on their directions and dipping) and 6) comparison between bedding, families of joints and cave survey data by stereographic projection. Seven families of joints have been defined in all the area of study. The joint families are: J1) sub-vertical, J2) N63/68SE, J3) N29E/46NW, J4) N52E/72NW, J5) N129E/17NE, J6) N167E/57NE and J7) N180E/26E; the bedding is N30-55/60-80NE. Five groups of cave passages have been defined. "A" group of cave passage is formed by sub-vertical series; it is represented by the 61 % of all the cave passages and is conditioned by the joint families J1, J3, J4 and J6, as well as their intersections. "B" group is formed by N10W-N10E/3-20N galleries; it corresponds with the 13 % of the series and is controlled by the intersection between families J5 and J6. "C" group is defined by N20-70E/0-50NE passages; it is represented by the 13 % of the cavities and is ruled by the intersection between families J1, J2, J5 and J7. "D" group is formed by N125-145E horizontal galleries; it includes the 6 % of the passages and follows the bedding. "E" group is defined by N105-151W/38-65SW passages; it is represented by the 3 % of the passages and is conditioned by the families J1, J2, J3 and J4. This work proposes a new methodology of work in speleogenesis based on the establishment of the quantitative relationships between cave survey with joints and bedding. The method shows some advantages when compared with other methodologies (e.g. statistically models based on structural analysis of the discontinuities of the rock massif or based on the Inception Horizon concept): it is a 3D analysis that can be applied on complex geological settings to make accurate estimations of the percentage of the caves controlled by each joint family and bedding.