



**19th International Congress of Speleology
38^o Congresso Brasileiro de Espeleologia**

Syllabus – Short Course

Practical Application of Empirical Geomechanical Classification Systems in the Structural Stability Analysis of Natural Caves: Advantages, Limitations, and Simulation of IGC and Q-Span Methodologies in an Iron Ore Cave in Carajás, Brazil

Luis Jordá Bordehore

Email: l.jorda@upm.es

Instructors: Luis Jordá Bordehore (Professor, Universidad Politécnica de Madrid) and Marcelo Roberto Barbosa (Researcher, CPGA-UFRJ)

Event: 19th International Congress of Speleology and 38^o Congresso Brasileiro de Espeleologia

Target Audience: Professional and amateur speleologists, as well as students and professionals in engineering and geosciences at all levels

Date: July 19th, 2025

Duration: 6 hours (including a 2-hour lunch break) – 9:00 AM to 12:00 PM and 2:00 PM to 5:00 PM

Venue: Room 3049, Institute of Geosciences (IGC), Federal University of Minas Gerais (UFMG)

Language: English, Spanish, or Portuguese



19th International Congress of Speleology 38^o Congresso Brasileiro de Espeleologia

Context

The stability of natural caves is a critical yet often underexplored topic, especially in the context of increasing tourism in caves and renewed interest in subterranean habitats, such as cave dwellings and underground hotels. Assessing structural stability is essential not only for safeguarding human lives but also to prevent costly disasters and minimize long-term environmental impacts.

Furthermore, strict environmental legislation, such as in Brazil, establishes protective zones around caves and mandates robust structural studies before authorizing any interventions in their surroundings. These regulations can significantly impact mining operations by imposing restrictions on mineral reserves located near cave systems.

A fundamental approach for preliminarily assessing cave stability involves empirical analysis using geomechanical classification systems. Since the 1970s, systems such as Rock Mass Rating (RMR) by Bieniawski (1973), the Q-System by Barton (1974), and Geomec by Laubscher (1984) have been widely applied in tunnels, mines, and caves, generating extensive data across various lithologies and regions. However, their use in natural caves remains limited. The Geotechnical Cave Index (IGC), recently developed by Brandi (2021), stands out as the only method specifically designed for this purpose.

These classification systems help evaluate rock mass quality by considering factors such as rock strength, fracture orientation, and groundwater conditions—all of which are critical in determining cave stability.

Program

This short course will provide a technical overview of these classification systems, highlighting their advantages and limitations when applied to natural caves.

During the course, participants will analyze the stability of at least three distinctly different caves:



19th International Congress of Speleology 38º Congresso Brasileiro de Espeleologia

- A touristic karst limestone cave
- A touristic volcanic cave
- An iron ore cave

The complexity of the analyses will progressively increase, with the instructor offering continuous theoretical explanations and promoting collaborative problem-solving.

As we cannot physically visit these caves to collect data, several caves have been digitized and will be explored in a virtual environment. In this virtual setting, data will appear through interactive pop-up menus.

Throughout the course, participants will receive practical and theoretical materials to help solve the various case studies. The following links provide articles and resources related to the course content:

<https://www.mdpi.com/2072-4292/15/3/732>

<https://www.mdpi.com/2076-3263/12/10/380>

<https://sketchfab.com/3d-models/cueva-en-estudio-fvt-2-8c0927a2660146178e1bcb12c750cb38>

<https://sketchfab.com/3d-models/cueva-en-estudio-fvt-56108b4eed2142528d68ddbcb876754>