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Microseismic Monitoring – An Approach to the Geostructural Assessment of Iron Caves in the Carajás Mining Complex, Pará, Brazil.

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Introduction

Brazil is the second-largest producer of iron ore in the world. The two main areas of occurrence of this mineral resource in the country are located in the Quadrilátero Ferrífero in the state of Minas Gerais and the Carajás Mineral Province in the state of Pará, Brazil. The region encompassing the Carajás mining complex, managed by Vale S.A. and the subject of this study, is characterized by the presence of natural caves developed in jaspilites, hematites, and ferruginous lateritic crusts (canga). According to Brazilian legislation, natural underground caves are federal properties and require specific technical-scientific investigations to licensing mining activities. Federal environmental laws establish a protection buffer of 250 meters to ensure the physical integrity of the cave and its area of influence until the entrepreneur carries out studies to define the real area of influence. However, this requirement often leads to the blocking of reserves and mine shutdowns, resulting in substantial losses for the mining industry until these scientific studies are approved.

Method and/or Theory

Currently, the greatest potential for damage to the physical integrity of the caves is related to explosives for blasting, associated with the advancement of mining. Given the need to understand the possible damages, which are fundamental to mitigate possible impacts on the speleological heritage, this work has already carried out studies in the N4E-0026 cave, representative of the Carajás iron plateaus, located in the N4EN mine, in the Carajás mining complex. The cave was subjected to an assisted suppression project, authorized by environmental agencies, which allowed a controlled approach of the operations in the mine until its collapse. In this context, a microseismic survey was carried out using an array of 12 geophones with continuous remote transmission, distributed over 150 thousand m² of the project area aiming an interferometric study.

Results and Conclusions

Microseismic monitoring was used during the controlled mining, in order to record the behavior of the seismic waves during the advancement of the operations and their influence on the physical integrity of the cave. The data obtained allowed defining a preliminary alert limit that preceded the structural compromise of the massif where the collapsed cave was inserted. The graphical results showed the evolution of the seismic velocity reduction in some geophones, under a continuous reduction of 0.5% in a 12-day interval between the beginning of the weakening of the shear modulus, until the total collapse of the cave. The waves of the passive seismic, in principle, demonstrate a similar behavior to conventional engineering seismographs, a fact that opens a possibility of substitution in future monitoring. The application of the unprecedented microseismic monitoring, showed an encouraging result as a complementary tool to traditional investigations, and made a strong contribution to the advancement of robust predictive models on geostructural assessment of iron caves and the integrity of their surrounding areas.