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A Electrical Resistivity, Microseismic and Geotechnical Monitoring of an Iron Cave Near a Diamond Drilling Campaign. Case Study at the N4EN Mine, Carajás, Brazil.

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Introduction

Mining in Brazil is subject to strict environmental laws regarding the protection of natural underground caves. An area of influence of 250 meters, centered at the cave, must be protected before technical studies, particularly those on the structural stability of these caves are carried out and submitted for licensing by environmental agencies, blocking a significant part of the mineral reserves. Even drilling campaigns require authorization and licensing by environmental agencies, which slows down exploration and geological knowledge of the reserves.

Method and/or Theory

An area of the N4E iron mine in Carajás, Brazil, operated by Vale SA, was selected for a pilot project with the aim of studying and monitoring an iron cave (N4E-0026), authorized by environmental agencies for supression. The motivation for this work was to study the possible physical damage that could occur inside the cave and/or in its surroundings during a drilling campaign within the cave's protection area. In order to achieve this, eight diamond drill-holes approximately 100 meters deep were planned to be aligned and spaced approximately 50 meters apart. The first hole was located 250 meters away, and the others were distributed evenly, getting as close as 50 meters from the cave. For monitoring these operations, data from three distinct sources were used, all implemented in the pilot project: (i) near surface geophysics, from a electrical resistivity survey on the ground, exactly over the cave, (ii) microseismic, from an interferometric array of 12 geophones covering the entire area, and (iii) geotechnical, from in loco structural mapping and remote geotechnical instruments for real-time measurement of fracture/discontinuity movements, using crackmeters, and floor-to-ceiling convergences using convergence meters.

Results and Conclusions

The electrical survey data revealed, through their resistivity and conductivity contrasts, points/zones of structural weakness in the ceilings and walls of the cave' spans, which remained clear of physical damage throughout the entire period of the drilling campaign. This absence of physical damage was also observed in the velocity variation lines from ambient noise seismic interferometry, which remained nearly horizontal without major disturbances throughout the entire drilling period. During the hours when the drilling rig was not operating, the lines presented the same pattern of behaviour without disturbance, indicating the preservation of the overall integrity of the massif. Regarding the geotechnical monitoring, the displacement graphs did not oscillate, detecting no movements in fractures/discontinuities or floor-to-ceiling convergences inside the cave. The geostructural mapping confirmed that the cave's surroundings have similarly retained their physical integrity. These results demonstrated that there was no physical damage inside or outside the cave, and that the integrity of the surrounding massif was not affected by the proximity of the drilling campaign up to a distance of 50 meters. These results are encouraging, both for drilling campaigns and for the preservation of the speleological heritage, since the physical and chemical characteristics of the lateritic crusts that host the Carajás shallow iron caves and their structural behaviour are quite similar throughout the region.