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Quick Structural Modelling Using Multi-Hole Borehole Image Analysis; A Critical Input in Mine Planning

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SUMMARY

The main objective of this study is to present the value of multi-hole borehole images interpretation in unlocking the structural configuration of the rock mass in a quick, yet effective way. This analysis revealed that the block is a small fold with moderately dipping limbs with a rock sequence of four main rock types or mechanical units. Fractures are developed only in one particular rock type showing the full control of mechanical stratigraphy on fracture/joint distribution. A fault gouge/broken zone was also identified and correlated in all three boreholes. These results were used to build a conceptual 3D model of the block accommodating both structural features and geotechnical rock types. This which was performed in only 2 days after the data acquisition can be used in any mining process particularly those requiring geological settings understanding of a specific location.

Key words: Borehole imaging, geology, multi-hole analysis, structural modelling.

INTRODUCTION

The purpose of this study is to demonstrate how a good, site-specific and quick understanding of the geological settings can be obtained using multi-hole borehole image analysis technique. This is a critical input in mining processes requiring structural and geotechnical knowledge of a specific location e.g. for geological underground mapping, slope design and blasting. High resolution borehole images are used to analyse three important features of the rock mass: (i) structural configuration (ii) defects orientation and spacing and (ii) geotechnical rock types. This information is then utilized to build a quick conceptual 3D model of the rock mass. Ultimately, it is discussed briefly the application of this geological analysis package.

METHOD AND RESULTS

We used high-resolution optical borehole televiewer images (OTV) to analyse the rock mass features in three nearby drill holes. These holes were drilled using diamond coring within a 1 km^2 block within a mining site targeted for blasting-associated excavation and slope design in Australia. Core data are broken and of limited use in structural geology analysis. Two holes (A and B) are deviated in almost opposite directions (both 20 deg towards East and West respectively), while the third hole (C) is vertical and covers only part of the studied interval. We classified major rock discontinuities/defects based on their nature and appearance on borehole images into bedding contacts, natural fractures/joints, and broken zones. One of the broken zones is inferred to be a fault gouge or shear interval.
The results of borehole image interpretation reveal that rock strata dip at two different directions, N30W and S40E with similar dip inclination of 30 to 35 degrees in the boreholes A and B respectively. Structural dip of the rock in the borehole C is 10 degrees toward N30E. We found that natural fractures are predominantly constrained within a particular rock type with beds of less than 20 cm thickness. These fractures show conjugate geometry with a strike of N40E and an average dip angle of 65 deg. The interpreted fault/fault zone dips at 50 degrees towards N40W. We computed the frequency of the features described above along the boreholes to show the defect spacing. We used the image colour components to extract an index of variations in lithology, which is called *Litho-index*. This litho-index basically reflects the variation of rock types vertically. This in combination with defect density reflects the competence of the rock mass or mechanical stratigraphy (Figure 1). We also computed aperture of the defects which gives average values of 11 mm and 1100 mm for fractures and broken zones respectively.

We used the results to build a conceptual 3D model of the rock mass within the target block. This model accommodates both structural configuration and stratigraphic composition. We classified rock mass into four main geotechnical rock types based on the defects identified and inferred rock composition; broken/weathered cover, incompetent argillaceous, brittle jointed and non-jointed bedded rock types. This model reveals that the block is a small fold (300 m half-wavelength) with highly dipping flanks. This specific structural geometry has a great impact on rock anisotropy (Figure 2).

CONCLUSIONS

- This analysis indicates that a robust multi-hole borehole image interpretation can provide a good understanding of geological settings (particularly structures) of a mining site in a quick turnaround time. We accomplished this study in a only 2 days after data acquisition. This can have great impact on decision making procedure and reducing cost. Also, presence of multiple broken zones and natural fractures did not impose any limitations on this study. Whereas, these items are the two major advantages over the core logging as an alternative.
- The 3D conceptual model we generated can serve as a crucial guide/verification for more detailed geological modelling using advanced softwares such as Vulcan. Although, this model is precisely matched with existing hard data and not biased with any software computation uncertainty range.
- This 3D model can be used in multilple mining operations such as drilling and blasting pattern designing and slope planning, where structural and stratigraphic settings play a critical role. For instance, since the structural dip is systematically high at two different orientations it is

recommended to consider inclined blastholes with trajectories normal to bedding on both limbs i.e. 30 to 35 degrees towards N30W and S40E. As suggested by Gokhale (2011) it has several advantages compared to usual vertical blastholes including minimizing dangerous back breakage.

- This study reveals that the fault zone is highly broken and fragmented. Therefore, it can act as a very unstable discontinuity in the block. This is a major input in slope stability analysis. Also, in blasting design, this zone should be considered as a plane causing noticeable energy splitting.

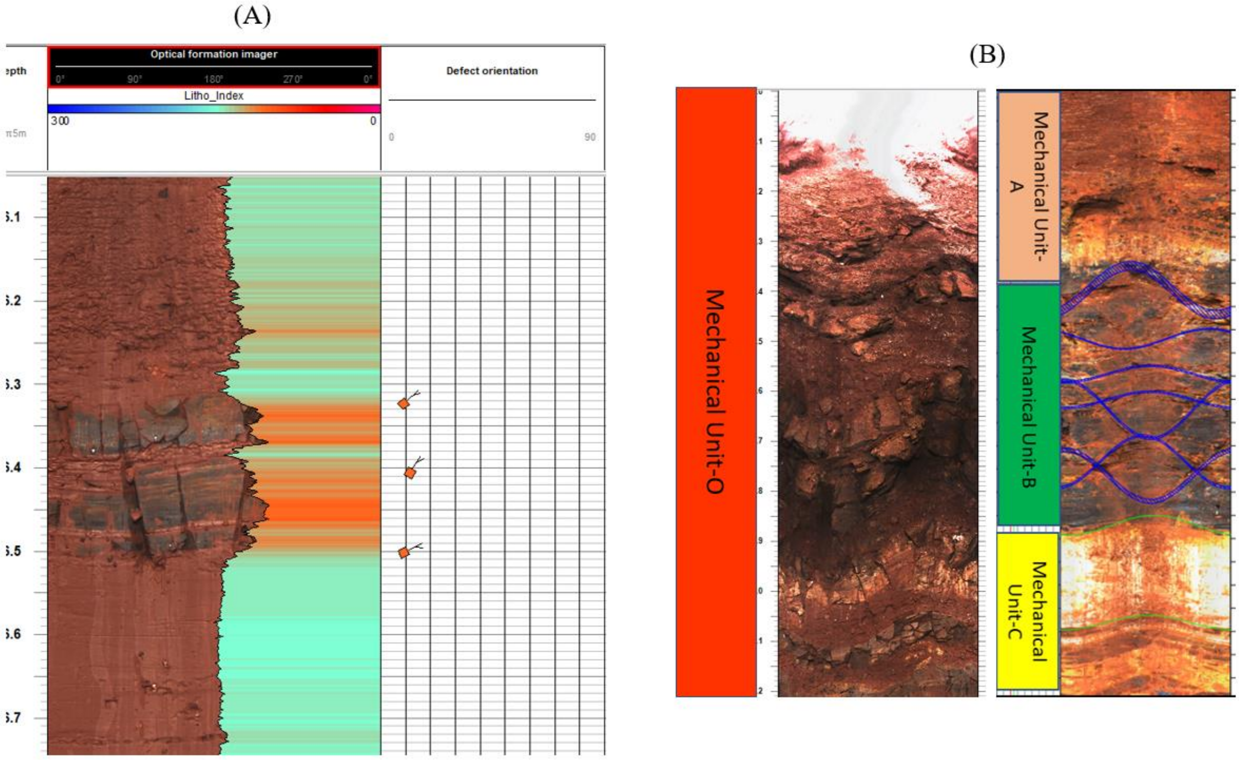

Figure 1: (A) Litho-index (color shading) curve can clearly discriminate rock units with different composition/texture and hence different competence. As it can be seen, joints are developed preferentially only in rock units/beds highlighted by orange color on the litho-index. (B) four main mechanical units found in this study.

REFERENCES

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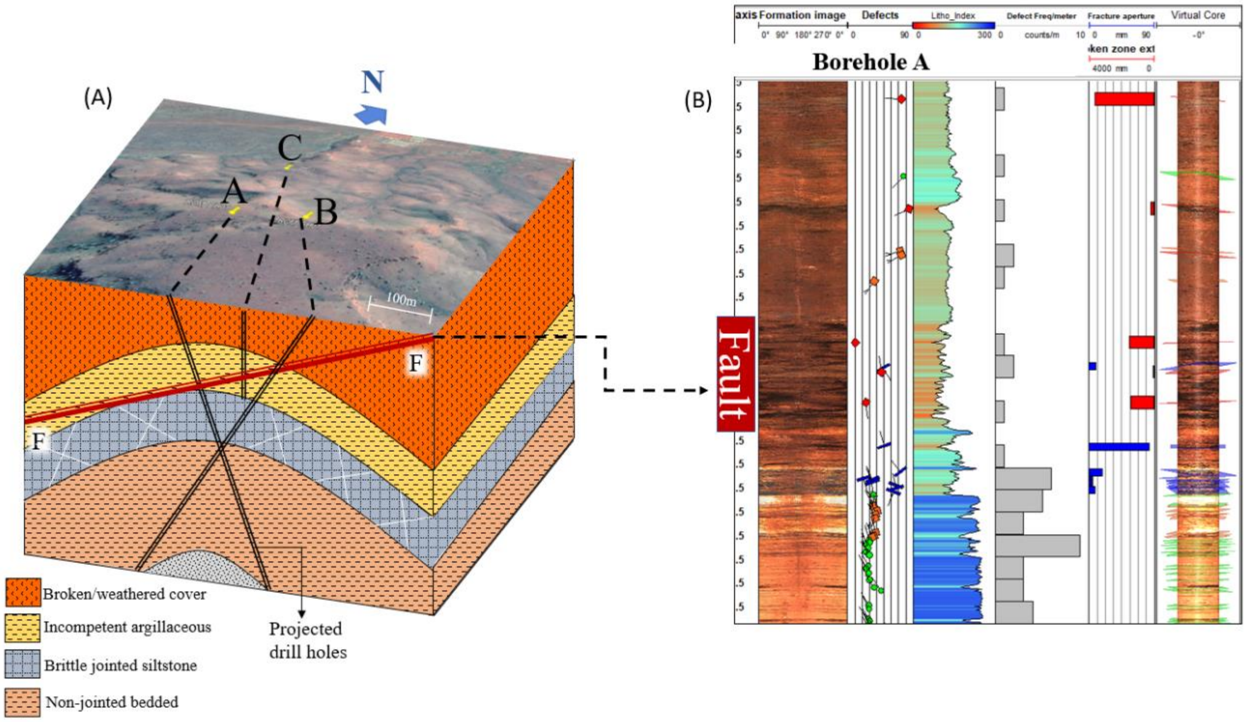

Figure 2: (A) conceptual 3D geological model of the block and (B) Interpretation composite plot of the borehole-A. Mechanical rock types are shown in the legend. Fractures are shown as white lines in the brittle jointed rock type.