Block modelling for the purpose of visualising geotechnical borehole data at Tritton Mines

S. Hayes[1], M. C. Pang[1] W. Hartman[1], and S. Fitzgerald[2].

[1]Geohart Consultants Pty Ltd., 5A Hartnett Close, Mulgrave, VIC3170, Australia; PH (61) 3 8562 2217; FAX (61) 3 9923 2746; email: wouter.hartman@geohartconsultants.com.au
[2]Straits Resources Limited, Tritton Mines, Yarrandale Road, Hermidale 2831 NSW; PH (61) 2 6868 1105; FAX (61) 2 6838 1101; email: sfitzgerald@tritton.com.au

ABSTRACT

Borehole logging data from Tritton Mine is utilised to develop a block model in which geotechnical data is interpolated to enable visualisation in 3D. Traditionally, geotechnical data such as Rock Quality Designation (RQD) and Modified Rock Mass Quality Tunnelling Index (Q' value) obtained from borehole logging is used in analysing the stability of underground openings (e.g. Mathews Stability Graph Method). The most representative data point from a borehole is chosen based upon the data considered closest to the point of interest. At Tritton Mine, an alternative approach has been used in a number of geotechnical block models to aid in the interpolation of geotechnical data amongst boreholes. The applicability of a block model is dependent on the choice of block size, search parameters and on developing appropriate geotechnical domains for use as constraints for such a model. A large block size can be useful for regional geotechnical understanding, while small block sizes are considered to be more appropriate for looking at localised scale. A number of block models using differing block sizes and search parameters were created and the block models were visually assessed together with the borehole data for optimum representation.

Keywords: Tritton, block model, inverse distance, geotechnical, RQD, visualisation

1. MINE BACKGROUND

Tritton Mines is located approximately 45km northwest of the township of Nyngan in central west New South Wales, Australia (Figure 1). The small town of Hermidale is located approximately 15km to the south of the mines.

Figure 1. Tritton Mines location

The Tritton Mines consist of the Tritton Mine, North East Mine and the historical Girilambone operations. The Tritton deposit is blind at surface and was discovered by drilling a geophysical anomaly. Mining of the Tritton ore-body commenced in 2004 with the development of a boxcut and decline. Stope production commenced in March 2005 and produced 23,088t of copper in concentrate in its first year of underground mining.

Up until mid 2010, Tritton employed an open stoping mining method, with a top-down 'outside–in' approach. In general, stopes were extracted in a retreating fashion using the ore-drives as access and draw points. A system of pillars (5 to 10m) was used resulting in an extraction ratio of approximately 75%. Recently a pastefill plant was commisioned and the mining method changed to a combination of transverse and longitudinal mining utilising the pastefill allowing total extraction.

Stable stope spans are designed using the Mathews Stability Graph which incorporates the modified stability number N' which is calculated based on geotechnical information gained from borehole logs.

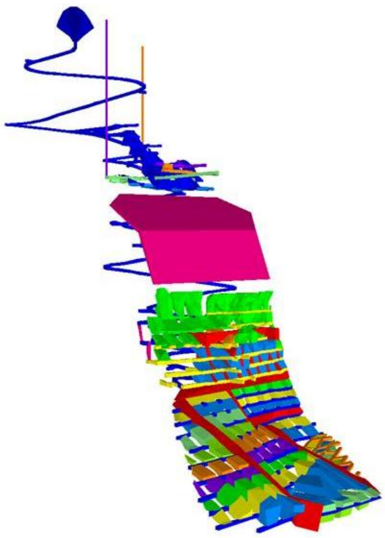

Figure 2. View of Tritton Orebody

Tritton is a primary sulphide deposit that has been tested to 1250 below surface and remains open at depth. Mineralisation has been interpreted to be approximately conformable with foliation, which strikes approximately north-south on the mine grid. The deposit dips at varying angles towards the east. Locally at the Tritton mine, the tabular sulphide body varies from approximately 5-30 metres in width but attains widths up to 100 metres at considerable depth.

The Tritton mine is considered to contain three broad geotechnical domains, namely, hanging wall, orebody and footwall.

- The hanging wall at Tritton consists predominantly of Quartzite, with marginal meta-sedimentary schist. In other sectors, the hanging wall is composed of predominantly Schist with minor Quartzite. The hanging wall is also lower strength compared to the orebody.
- The orebody consist of a Sulphide and is considered high in strength, hard and brittle.
- The footwall consists mainly of Quartzite and Schist and is considered much softer, and has much lower strength.

2. BLOCK MODEL AIMS

Conventionally, when geotechnical borehole data such as RQD is required for analysis, sections are plotted out to determine (within a certain distance) which boreholes are relevant to the area of interest. The geotechnical information at the area of interest is generally selected from the available boreholes. There is usually no standardised method to accurately determine which borehole data to be used, and no way of weighting the more relevant data.

By creating a block model, this process of determining the best relevant geotechnical data available at a given location is carried out in a systematic way. The aim of this study was to determine the most representative way to develop block models for the Tritton Mine.

A separate block model for each geotechnical domain (hanging wall, orebody and footwall) was created based on the RQD values from the available geotechnical logs. The geotechnical block modelling using the RQD data was chosen to perform as there was more available data in the drillhole database than other geotechnical data. Also, RQD data has not been manipulated reducing the possibility of calculation errors affecting results. The effect of using different block sizes and search parameters on the block models was also compared.

3. METHODOLOGY

3.1 Validation of Input Data

The RQD values within the borehole database provided by Tritton Mines were reviewed and classified into different domains which were hanging wall, orebody and footwall. Some rounding errors were found in the database and the RQD data with values between 101 and 105 were considered acceptable because such RQD values could be caused by inaccurate measurement in drilling depth or core-length of particular core-runs. The borehole data that had values of RQD above 105 or blank were eliminated.

3.2 Interpolation

The computer program Surpac^{TM} provides several interpolation methods. Possible interpolation methods for the RQD data considered were either “nearest neighbour” or “inverse distance”. The nearest neighbour function was not selected because the interpolation is solely based on the nearest RQD data, hence there is no consideration of other RQD data in the vicinity. The inverse distance function was considered to be a more appropriate method as the function calculates the RQD value for each voxel (block) by examining the surrounding data within a user defined search radius. The value of inverse distance power was taken to be 2 because high inverse distance power values will over exaggerate the influence of the source data to the interpolated value.

3.3 Search Parameters

Separate block model was run for each domain so as not to allow cross-contamination of data over domain boundaries. In order to compare the effect of block size and search parameters on the results, three block models were run.

The search ellipsoid can be either isotropic sphere or anisotropic ellipsoid, in which, the anisotropy ratios varies in different directions. As the anisotropic characteristics of RQD data values at the mine were unclear, Models 1 and 2 were run with the same block size, but differing anisotropy search parameters. For Models 1 and 3, the orientation of the anisotropic ellipsoid was assumed to follow the orebody as it was considered reasonable that spatial variation of RQD data values may follow the orebody in view of the geological setting.

The input parameters for each block model are shown in Table 1. Only the results for the hanging wall domain are presented in this paper.

Table 1: Input parameters for block modelling

	Block size			Sub block	Interpolation method	Search parameters	
	x	y	z			Search radius	Search anisotropy
Model 1	10m	10m	5m	None	Inverse Distance	50m	Anisotropic ellipsoid
Model 2	10m	10m	5m	None	Inverse Distance	50m	Isotropic sphere
Model 3	5m	5m	3m	None	Inverse Distance	50m	Anisotropic ellipsoid

4. MODEL RESULTS

4.1 Overall interpretation

Model 1 and Model 2 (Figure 3), which use the 10m x 10m x 5m block size, show that results have been interpolated for the areas surrounding the available data. Towards the deeper parts of the mine there are areas in which the data is simply too far apart to interpolate the entire area between boreholes. In the upper parts of hanging wall where more RQD data is available, both block model results are quite uniform. Model 1 using anisotropic data search shows a possible linear feature somewhat more clearly than Model 2 using isotropic data search.

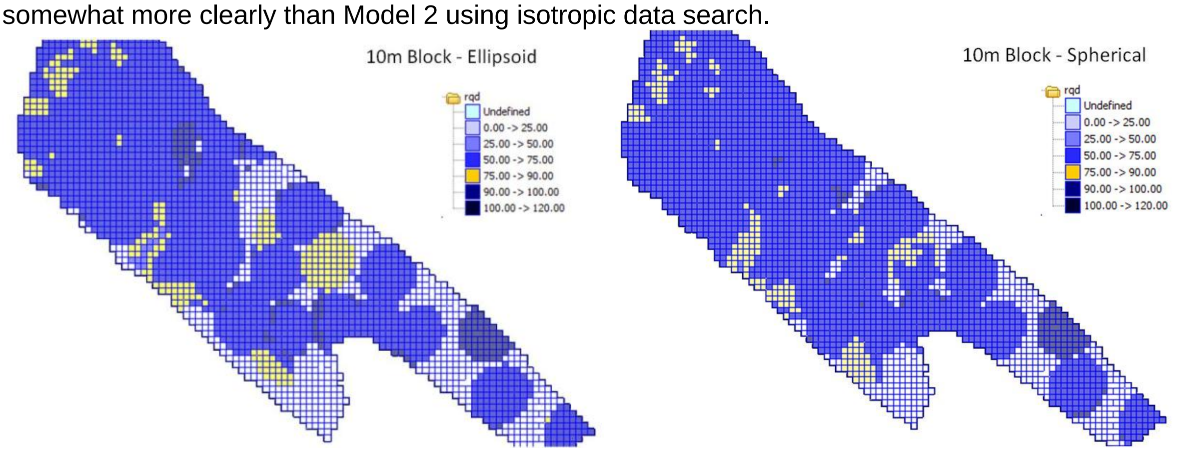

Figure 3. Comparison of estimated RQD values in plan view between Model 1 using ellipsoid data search (left) and Model 2 using spherical data search (right)

In Figure 4, the spatial distribution of the interpolated RQD values using a 5m x 5m x 3m block size (i.e. Model 3) was similar to the 10m x 10m x 5m block size used in Model 1. The detail of the previously mentioned linear feature is more pronounced in Model 3 with smaller blocks.

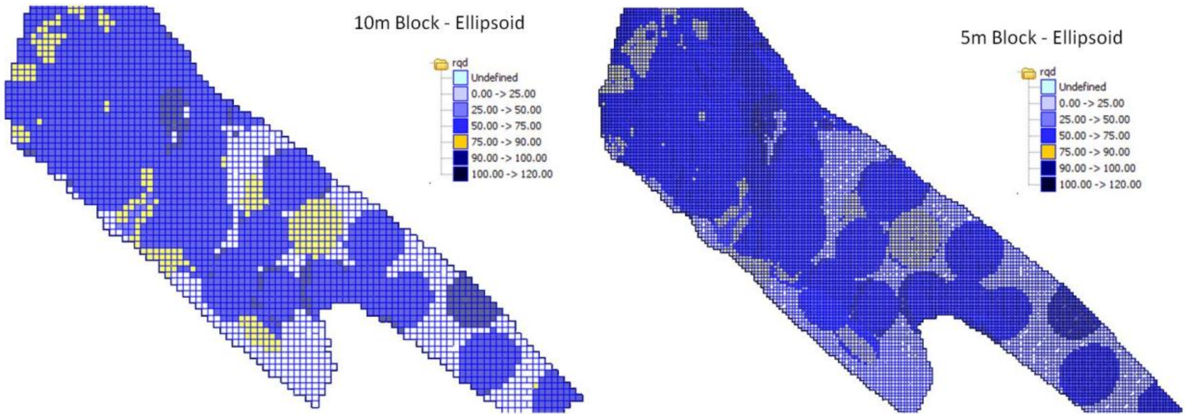

Figure 4. Comparison of interpolated RQD values in plan view between Model 1 using a 10m x10m x 5m block size (left) and Model 3 using a 5m x 5m x 3m block size (right)

4.2 Comparison to known structures

Both the 5m x 5m x 3m and 10m x 10m x 5m block size anisotropic models (Model 1 and Model 3) indicate one geological structure quite well. However, it did not seem to pick up any of the other major structures (see Figure 5). The reason for this could very well be related to the drillhole density.

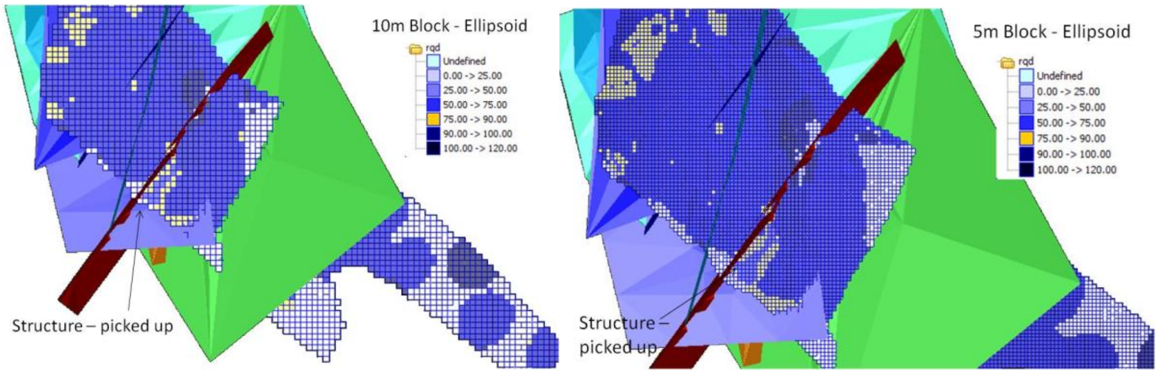

Figure 5. Pick up of a structure in Model 1 (left) and Model 3 (right)

4.3 Comparison with borehole data

In Figure 6, the 10m block size anisotropic model (Model 1) showed reasonable good correlation to the borehole RQD data values when assessed over a few tens of metres. At the actual pierce point where the borehole intersects the block may however differ in value from the block value. This is because the block model smooths the data to some degree.

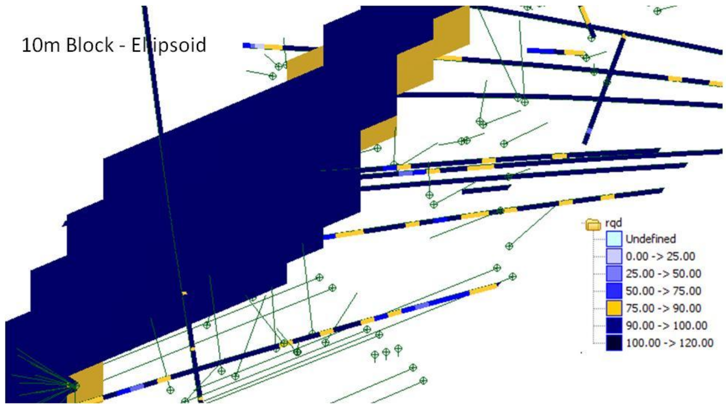

Figure 6. Comparison of interpolated RQD values in Model 1 and borehole RQD data

In Figure 7, the manner in which the blocks derive their value, based on equally weighted borehole data from all directions, can be seen. The block values show more consistency away from the orebody in the isotropic model.

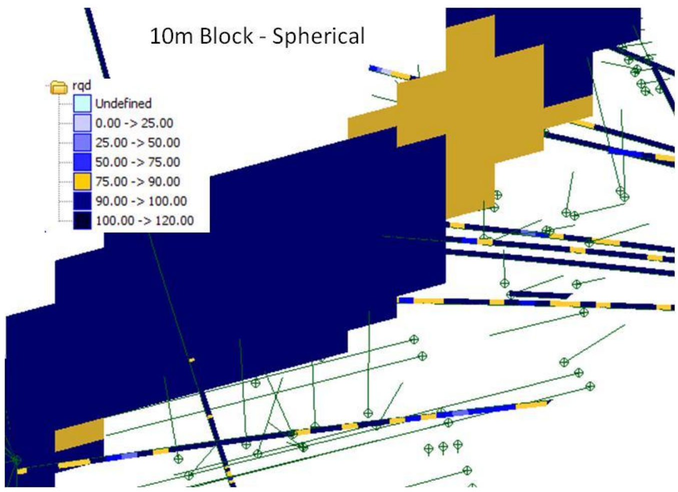

Figure 7. Comparison of interpolated RQD values in Model 2 and borehole RQD data

For Model 3 with the 5m x 5m x 3m block size (Figure 8), over a scale of tens of metres, the resulting RQD values are very similar to those modelled in Model 1 using the 10m x 10m x 5m block size. This is possibly due to adopting the same search radius had not been changed.

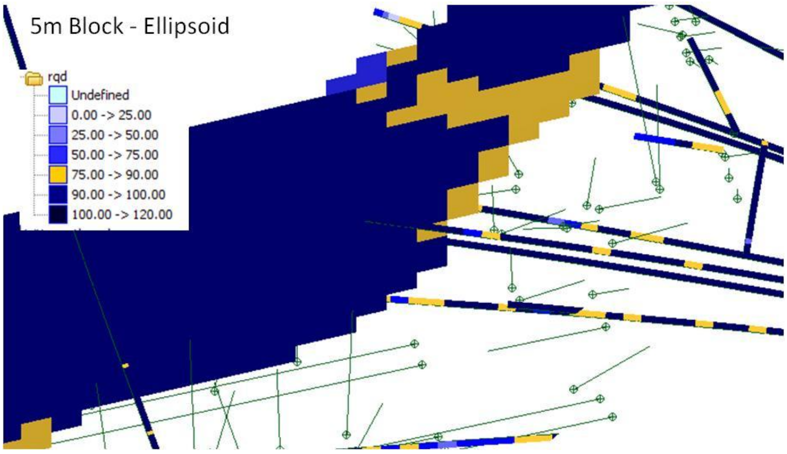

Figure 8. Comparison of interpolated RQD values in Model 3 and borehole RQD data

5. DISCUSSIONS

The block models were visually assessed together with the borehole data for optimum representation. The created RQD block models, based on the provided borehole logging data, are considered reliable to indicate rock mass conditions up to a scale of tens of meters. The interpolated RQD values are smoothed overall. Particularly, the isolated low RQD values in the data set might be “masked” if they were surrounded by high RQD values.

5.1 Block size choice

A 10m x 10m x 5m block size would appear sufficient if aiming to examine the data generally for stope spans between 20m and 40m. Using this block size may also indicate areas where there is insufficient data collected and where some infill drilling and logging may be useful. This block size may need to be reduced if the geotechnical properties of the rock mass are particularly variable.

5.2 Selection of search parameters

The search parameters adopted could considerably affect the model results. In the case of Tritton, the RQD source data was not very variable hence the influence was not very obvious. The parameters for defining anisotropy must be very carefully chosen in order to correspond with the spatial variation of rock mass properties. If the anisotropic characteristics of data are unknown, the data can be assumed to be isotropic for initial preliminary block models.

6. CONCLUSIONS

Block modelling based on available borehole data provides a gateway to estimate rock mass conditions. Through visualising the spatial distribution of interpolated geotechnical data like RQD in three dimensions, the understanding of rock mass conditions is enhanced. Block modelling can also be used to verify the level of confidence in the data. In order to work out the most suitable search parameters, a detailed understanding of the anisotropic characteristics of source data is required.

7. ACKNOWLEDGEMENTS

The authors would like to thank the management of Straits, Tritton Mines in granting permission to present the block models and the associated data.

8. REFERENCES

Bye, A. (2005). “The strategic and tactical value of a 3D geotechnical model for mining optimization, Anglo Platinum, Sandsloot open pit.” The Journal of the South African Institute of Mining and Metallurgy, vol 106, 97-104.

Geohart Consultants (2011). “Final report: Development of a geotechnical block model for Tritton and North East mines”. Geohart Consultants, 44p.

Hutchinson D.J. and Diederichs, M.S., Cablebolting in Underground Mines, pp 222 to 230.

Luke, D. A., Edwards A. (2004). “Geotechnical block modelling at BHP Billiton Cannington Mine.” Ground Support in Mining and Underground Construction, A. A. Balkema Publishers,129-137.