

Geotechnical data collection and presentation – it starts and ends with a vision

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The quality of geotechnical data collection is the first step towards minimising uncertainty

In the words of Stephen Few, a world leader in the field of data visualisation, business intelligence and decision support who focuses on the effective analysis and presentation of quantitative business information, 'Numbers have an important story to tell. They rely on you to give them a voice' (Few, 2009).

The foundation of a successful cave mining operation is the collection of detailed geotechnical rock mass and structural data. This fundamental data is used as the basis for fragmentation and cavability assessments on which significant mine design decisions are based and which can ultimately have an impact on the safety and economics of ore recovery.

Considerable improvements and technical advances in analysis and design have been made but are compromised by poor quality, quantity and understanding of the geotechnical data collected. The importance of detailed geotechnical and structural logging of an adequate number of drill holes cannot be underestimated. Combining robust data collection with appropriate software toolsets to visualise, interrogate and develop geotechnical models is important for yielding the maximum value and understanding of the data, including limitations, which ultimately feed into the mine design and decision making process.

Importance of detailed drill hole logging

Adequate time and planning is required for a successful drilling campaign. This includes a detailed plan communicated to the personnel involved prior to starting; sufficient resources, facilities and equipment to complete the logging; and an appropriate logging system for the capture of the required data in a format for easy input into the geotechnical database. A logging reference manual should be compiled that describes the data capture process and workflow to ensure that all required information is correctly described from the start (to prevent later rework) and avoid unnecessary assumptions during the data validation and analysis stage. It is important to use suitable experienced personnel in conjunction with a customised logging reference manual to ensure that the geotechnical data and structural measurements are collected correctly, to the required detail and in a consistent, auditable format.

It is common to encounter poorly planned geotechnical logging programs that have been conducted by inexperienced personnel, with little guidance as to how to collect the data and little to no continuous quality control. This results in a poor-quality geotechnical database. The database quality is typically only verified and validated during the analysis stage, long after the logging has been completed. By this stage, the database requires manipulation and assumptions to be made to make up for the inadequate data collection. This leads to potential errors in the analysis results and flawed inputs for high-level technical caving analysis tools and techniques, which have the potential to affect mining method, layout selection and cavability assessments.

In terms of caving studies, the importance of a detailed, well-planned data collection process that is, in most cases, customised to the type of deposit cannot be over emphasised. This goes hand in hand with knowing the limitations of data collection techniques and the management of geotechnical databases, even when the data collection process goes to plan.

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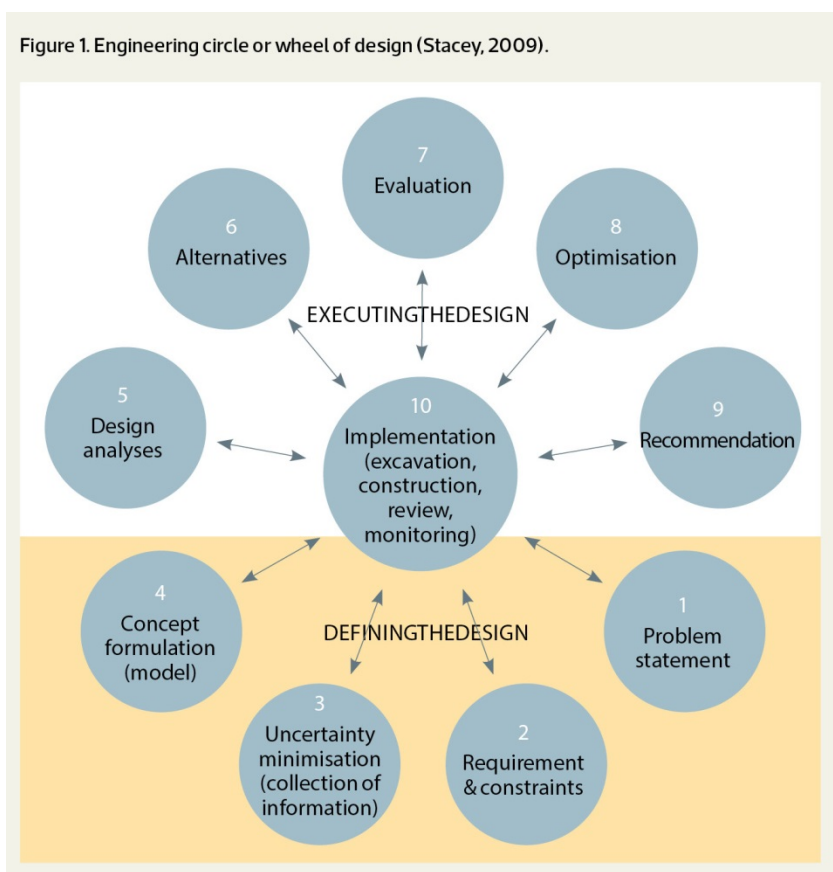
Louie Human and Ben Jupp

For a typical geotechnical core logging program for caving study purposes, the core is geotechnically domained and logged on intervals not exceeding 3-5 m. In addition to the target area, the geotechnical logging should include the overburden. Basic geotechnical information collected includes core recovery, rock quality designation (RQD), rock strength, weathering and alteration of the rock mass. In addition to the typical structural logging of oriented core, caving studies require detail on the discontinuity, frequency and strength of cemented joints and micro defects. This detail is required for primary and secondary fragmentation analysis, and if it is not adequately logged, it can result in an underestimation of the fragmentation profile.

Field point load testing should be conducted on the drill core at regular intervals, with descriptions of the mode and structure controlling the sample failure. Representative laboratory testing of the orebody and host rock should be completed as a comparison with the point load testing data. The laboratory testing is typically divided into lithological boundaries and should be of a sufficient quantity for statistical analysis. High-quality photography of wet and dry core with a consistent set-up and lighting should be used for visual record and reference prior to sampling or splitting of the drill core. Once the geotechnical data has been collected, validated and analysed to derive rock mass classification values and design parameters, the data is used as inputs into the engineering design process.

Engineering design process

Stacey (2009) described the engineering design process as a cycle containing ten steps divided into two stages. The first stage is defining the design, while the second is executing the design, with an iterative relationship with the implementation step. Geotechnical data collection is an important part of defining the design and minimising uncertainty in the final mine design (Figure 1).



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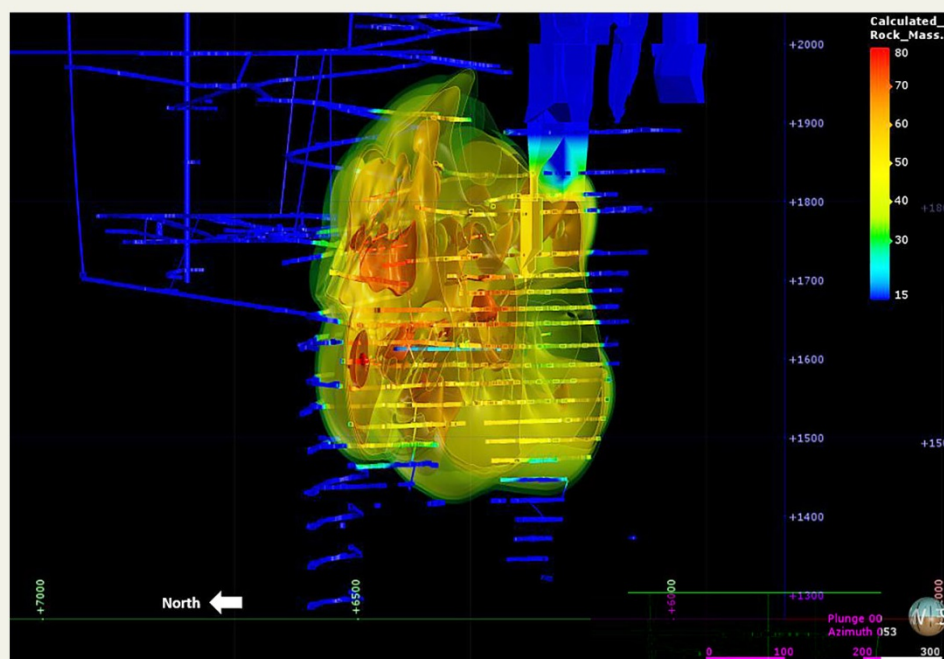
While all design aspects are important, the keys to minimising uncertainty are the quality of data collection (Step 3) and the best use and understanding of the data using available techniques to bring the traditional spreadsheet or database tables to life in a central 3D model. Such models provide a conceptual geotechnical model of the area of interest and make the understanding of the data in a spatial context possible.

3D data assessment

Beyond robust data collection methods, the analysis and evaluation of geotechnical data remains fundamental to the engineering design process. Integration and visualisation of geotechnical data in 3D space provides a valuable method to understand the spatial relationships of the data. 3D modelling software packages such as Leapfrog™ provide powerful and flexible toolsets that facilitate rapid import, visualisation and analysis of these datasets and enable integration of other multi-disciplinary datasets into one common space. In addition to powerful visualisation toolsets, the Leapfrog modelling package provides rapid 3D modelling functionality through its implicit modelling engine (Cowan et al, 2003). This functionality enables datasets to be modelled in reasonably short time frames, facilitating the definition of structural features and rapid creation of geotechnical domains. From this, geotechnical characteristics, ground conditions and their distributions can be quickly understood and relationships can be defined.

Using Leapfrog's implicit modelling function, numeric datasets such as rock strength, RQD, fracture frequency and rock mass classification values can be rapidly modelled as 3D wireframes. The implicit engine rapidly interpolates numeric data, essentially contouring the data in 3D space while honouring the logged drill hole information. In this way, geotechnical domains can be defined, evaluated and compared against the proposed cave design, location of mine infrastructure and ground support design (Figure 2).

Figure 2. An example of interpolated rock mass distribution domains with colour-coding on mine infrastructure.

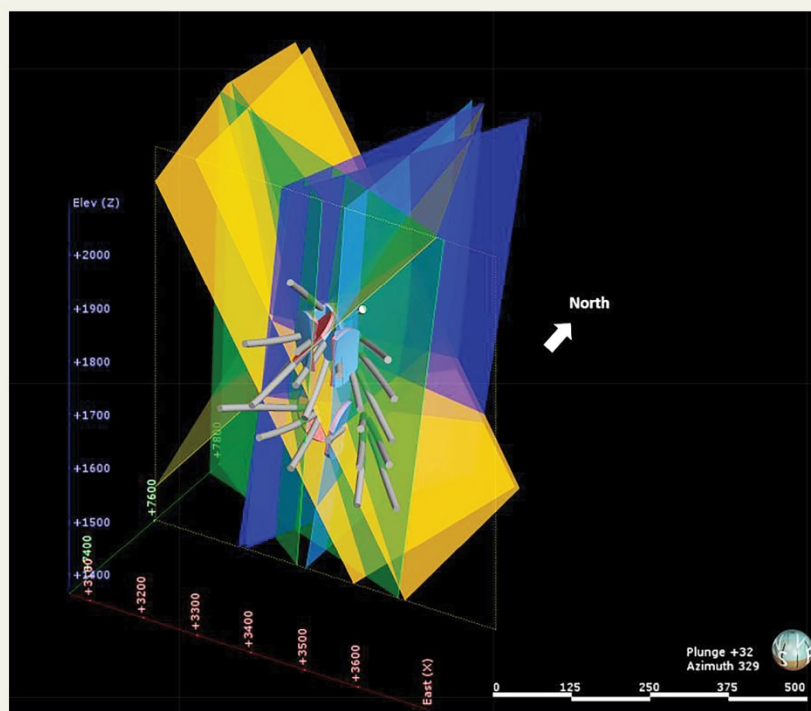


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The definition of a structural framework is fundamental to underground mine design as structural features – such as faults, fractures and joints – may control the behaviour of rock mass at depth. In Leapfrog, discrete planar objects, such as faults and joint sets, can be modelled directly from measured orientation datasets from the drill hole database, enabling the distributions of these features to be evaluated against proposed mine development (Figure 3).

Figure 3. An example of a modelled fault network based on geotechnical fault measurements.



Detailed geological modelling underlies the resource estimation process as it provides the fundamental geological framework that defines ore and rock mass quality controls and distributions. In addition, these lithological horizons and structural features play a key role in the rock mechanics within the mine space. Being able to integrate geotechnical datasets into the broader 3D geological context of the mine space enables analysis of lithological controls on rock mass quality and fracture development, which may also affect the mine's fragmentation profile.

In addition to being a valuable tool to visualise and analyse geotechnical datasets, 3D modelling enables key gaps in knowledge to be identified. It also highlights areas where further drilling and/or geotechnical work may be required. Understanding these knowledge gaps and addressing these at an early stage in the mine design process can help reduce key uncertainties and risks with respect to the mine development process.

Summary

The quality of geotechnical data collection is the first step towards minimising uncertainty and forms a fundamental input to the advanced technical assessment and design process used in the design of a caving operation. It is important to have an established vision with clear goals defined prior to planning a data collection program. This should be integrated using 3D visualisation tools to facilitate rapid import, visualisation and analysis and may be integrated with other multi-disciplinary datasets into a single common space. Ideally, this should be conducted while drilling and data collection are in progress and forms part of the data validation process as the conceptual visualisation of the data model unfolds.

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