

# Adding value using representative geotechnical models for mine design

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**A geotechnical model is the fundamental basis for the design of open pit and quarry excavations. A fully understood and representative geotechnical model will provide information on the engineering characteristics of the rock mass, defining how it is going to behave during and after excavation.**



Developing a geotechnical model is crucial to the design of open pit and quarry excavations

**T**he geotechnical model is composed of individual domains, each comprised of materials exhibiting internally similar geotechnical properties. Defining these domains and fully understanding what is critical to the excavation and the associated risks will enable the mine planners to design the optimal excavation slopes.

## Defining domains

A geotechnical model that will add value to a mine design should be developed based on a thorough understanding of the geology, structure and, where relevant, alteration and weathering states of the deposit and how these

impact the engineering properties. The geotechnical model should also consider the hydrogeological and hydrological conditions of the deposit and the rock mass data which characterises the rock mass conditions.

The geotechnical specialist should have a good understanding of the risks and limitations of the models for each of these criteria and how these will impact on developing the geotechnical domains. For instance, it is critical to understand the hydrogeological conditions and the rock mass strength for weaker rock deposits containing weaker sedimentary or highly altered rocks, as high pore pressures will have more of an effect on the stability of the slopes. For stronger rock masses,

however, it will be critical to understand the large and small scale structures as these will be the driving factors for the slope design.

Having the appreciation and understanding of the various criteria will enable the geotechnical specialists to determine the best approach to developing representative geotechnical domains that will add value to the excavation design.

## Advancements in modelling approach

Until very recently, the standard for constructing geological (including the base geology, alteration, and weathering profile) and structural models for use

in geotechnical domaining was based around explicit modelling techniques using CAD applications to manually define 2D cross sections which are subsequently linked using tag lines to form 3D triangulations.

Recent developments in software, however, have revolutionised this traditional modelling workflow, allowing models to be built in a true, open 3D environment. This move into the 3D realm has been accompanied by the evolution of geological modelling packages, which hardwire geological rules such as relative age relationships, fault offsets, contact types and other fundamental geological relationships into the modelling process. This is typically achieved through the use of implicit or semi-implicit modelling routines, using software driven algorithms to define surfaces and volumes without the need for manual digitisation (see Figure 1).

The modelling routines are guided by the geologists input through data selection, the application of trends, and definition of geological rules, and the resulting surfaces can typically be readily manually edited by the modeller.

The advantages of this approach are numerous:

- Working in a true 3D environment tends to result in more realistic models, particularly when interpreting complex 3D trends which may not be immediately apparent in 2D.
- Models will rebuild automatically to include new data or geological rules.
- Models reflecting multiple interpretations of a deposit can be produced concurrently.
- Data from multiple sources (downhole contact data, mapping strings, structural data, etc) in any spatial arrangement can be used to generate a single surface.



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- Implicit modelling is very fast and can incorporate larger data sets in much less time than was previously possible.

**Key considerations**

The variation in geological environment and quality, quantity, and type of data available, means that there is no standard workflow that fits every geological or structural model. However, whatever software used, whether explicit or implicit, some key considerations should be taken into account in building any model:

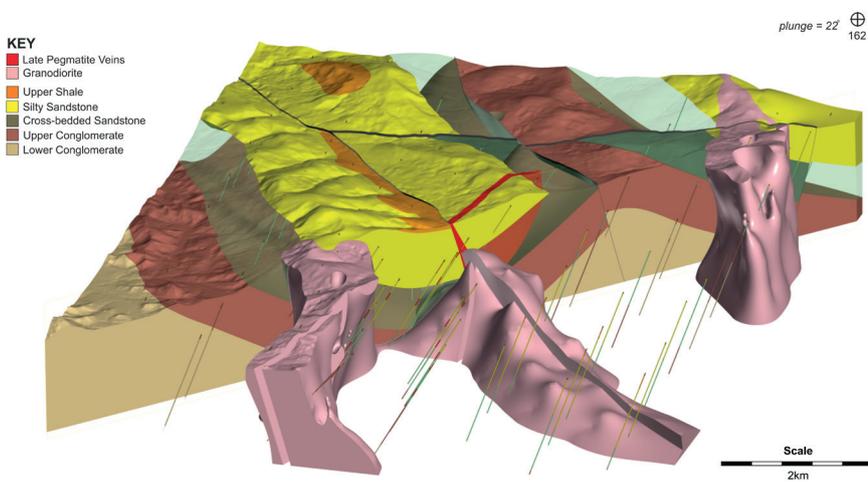
- Domain resolution – to what degree should the base data be grouped to produce a meaningful model of reasonable continuity, without resulting in an over-simplification of reality.
- Use all available data – not just drilling. Often, mapping and accompanying structural data, particularly from existing excavations or in well-exposed areas, provides much more detail than drilling alone.

- Think carefully about which modelling technique to employ – different methodologies suit different data and deposit types. For example, stratigraphic modelling routines are well suited to weathering profiles with widely spaced data, whilst a more implicit indicator modelling approach may be better suited to complex intrusives intersected by a large number of drillholes.
- Don't get bogged down in the detail too early – establish and construct the overriding model framework before focussing on smaller scale features.
- Validate – always validate the model against all available data. The model should not just match the drillhole data, but reflect the understanding of the regional and local geology and structure and be consistent with other available data.

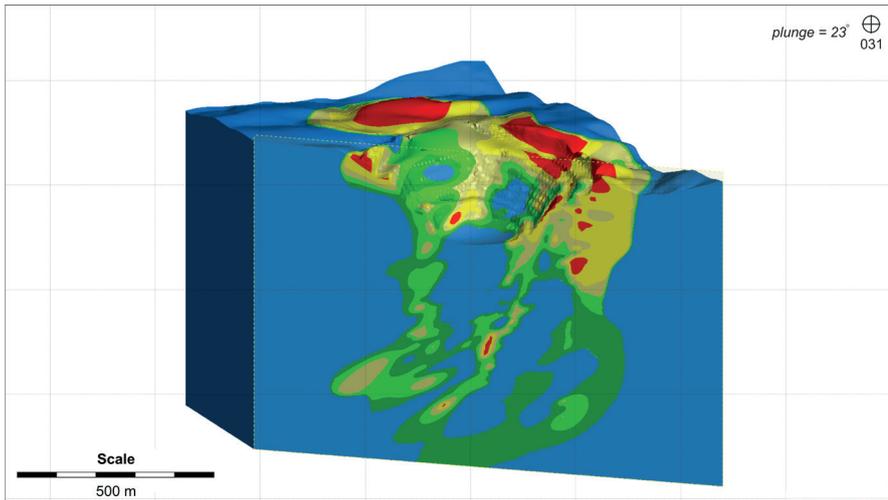
**Geotechnical analysis**

Only with robust and appropriate geology, structure and, where relevant, alteration, weathering and hydrogeology models, can the geotechnical specialist properly assess the rock mass controls. Geotechnical data should be spatially and statistically analysed relative to these models to understand how the geology and structure is affecting the rock mass engineering properties. At this stage, the geotechnical specialist should be able to decide what is controlling the variability in rock mass characteristics and use the geology and structure model to determine the best approach for generating the geotechnical model.

More complex models may require sub-domaining based on the spatial distribution of geotechnical parameters such as Rock Quality Designation (RQD), Fracture Frequency (FF), Rock Mass



**Figure 1** An example of a geological model, offset within a fault network, constructed using a contemporary geological modelling workflow

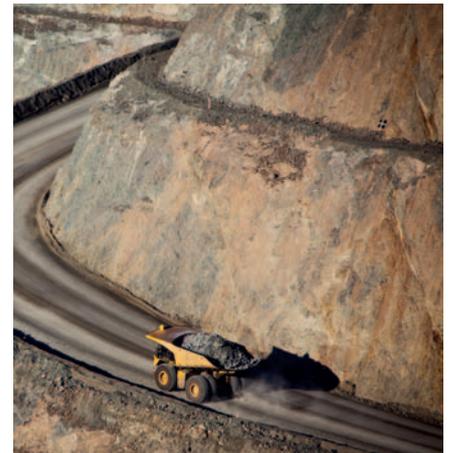


**Figure 2** Implicit modelling of RMR data in an open pit environment to better understand the spatial distribution of the rock mass quality

Strength (RMS) and Rock Mass Rating (RMR). This type of modelling should take into consideration the controlling geometrical trends such as major faults in certain orientations or controlling alternative strong and weak rock layers. This is often achieved through implicit interpolation techniques, which, with appropriate trends and controls in place, can be used to model numeric geotechnical data to more accurately define zones of poor or strong rock mass

within individual geological domains (see Figure 2).

Once finalised, the data in each geotechnical domain is used to define the geotechnical design parameters for the mine planning, consisting of overall slope angles based on batter and berm configurations, rippability and blastability of the rock mass considering rock strength, and understanding of the small scale structure and for locating critical infrastructure both inside and outside the excavation.



The geotechnical model will provide information on the engineering characteristics of the rock mass, defining how it is going to behave during and after excavation

The real value added to the mine planning comes from a succinct and in-depth knowledge of the development of and use of individual models to create a geotechnical model that is representative of the actual conditions. This is not an easy task and you need to think outside technical expertise and develop an appreciation of what is actually required to develop a robust geotechnical model.

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