Case study: Rapid visualisation and modelling of geological data

The rapid development of a 3D model has been a goal in MMG’s exploration programs to speed up the decision making process by exponentially increasing the rate and breadth of the data consumption by the geologist. The ease and speed at which a geological model can be built has far-reaching implications in the exploration process, as it means the greater part of the workload can be directed at formulating and testing geological hypotheses, and thus generating meaningful targeting criteria for further success.

There is increasing pressure throughout the mining industry to produce results using fewer resources. In terms of modelling, this translates directly to less time generating accurate and meaningful products. In this climate, an explicit modelling approach can very easily lead to a lack of detail in a depositional model. Where consultants are used for producing explicit models, a culture of external expertise is fostered, where very few in-house geologists study the resulting model in any detail. Using an intuitive implicit geological modelling package, such as Leapfrog®, has allowed MMG to expand the modelling expertise, with many exploration geologists taking on their own projects at varied levels of complexity and adding value with relatively little effort or time investment.

We have found that using Leapfrog for implicit modelling has resulted in an increase in the speed of the modelling process by an order of magnitude for many geological scenarios. The generation of simple objects has never been easier or more accessible. Directly using raw data, which has previously proven tedious at best, is now streamlined to the point of being transformational for exploration projects.

3D modelling is still in its infancy at MMG Exploration. The generation of solid volumes is handled by the resource department who use explicit methods in order to maintain a standard across the organisation. While Exploration has started modelling some solid volumes implicitly, the real value for us has been in the use of Leapfrog Geo and Mining earlier in the process. Ideas are easily drawn from the modelling before it is regarded as complete.

We are developing workflows that promote positive feedback loops in implicit modelling and geological understanding, which is moving us towards our vision of ‘Every geologist using 3D every day’.
THE VALUE OF FAST AND INTUITIVE DATA VISUALISATION AND VALIDATION

Simple 3D data visualisation is an incredibly valuable tool for geologists by making complex trends instantly recognisable (Figure 1). Many explicit modelling environments require significant training and data manipulation in order to display meaningful information. Leapfrog Geo has developed interfaces that allow large and complex datasets to be inspected and interpreted using intuitive, fast, and easy-to-learn tools. This has resulted in a far wider range of geologists gaining the confidence to push their understanding into a 3D environment, generating meaningful interpretation that can be shared with peers.

In any model, data validation is a key step to a robust final product. However, as it is often tedious, validation is sometimes completed with less rigour than it should be. Many 3D environments require most raw data to be validated manually or with only partial automation within a database or spreadsheet, applying Boolean rules. This approach cannot guarantee an error free dataset and can be days of work to simply view drillholes in 3D. Common issues include drillhole collars floating in mid-air (Figure 2), subtle survey errors, and irregularity in assay values that can be missed in a normal rule-based validation as thresholds are often not representative of all situations within a project. Leapfrog software takes a different approach, where validation is conducted within the 3D environment. This allows many data issues to be detected and fixed visually by geologists with very little 3D experience whilst simultaneously gaining an understanding of why the validation process is so important. This gives geologists a greater sense of data ownership, feeding into better collection practices, more confidence in the final products generated from the modelling process, and improved buy-in and involvement from all stakeholders.

INTERPRETATION DIRECTLY WITHIN THE MODELLING ENVIRONMENT

The speed of the implicit processing offered in Leapfrog Geo has allowed geologists at MMG to conduct sectional interpretation with greater accuracy. While ‘pencil and paper’ interpretations still provide a certain element of freedom not yet integrated into scientific software, the ability to flick between variables, downhole logging fields, and geochemical calculations directly from ioGAS has proven to be enough incentive to conduct 2D and 3D interpretation directly within the 3D view.

02
FIGURE 2:
Drillhole collars before and after a visual comparison in 3D with an accurate DEM. Database errors such as these are not picked up in an automated validation process.

01
FIGURE 1:
NEIC Earthquake Database displayed in Leapfrog Geo after a spherical transformation. A fast, easy interface is critical to allowing an increase in the number of geologists able to conduct their own studies.
An implicit modelling environment comes to the fore with the ability to instantly propagate the interpretation from the previous sectional work onto the current area of interest, and while useful for regularly spaced and oriented interpretation, this becomes an essential tool if using perpendicular, oblique, or inclined sections, where conducting such a task on paper has proven inaccurate on many projects. The task has become iterative, where ideas are passed back and forth across datasets, areas, orientations and geologists, resulting in a far more robust interpretation than would otherwise be accomplished.

**SPEED OF MODELLING SOLID VOLUMES**

The implicit approach has proved to be far more efficient than modelling explicitly in many situations. A particularly good case study at MMG is that of a stratiform deposit where a requirement was given to maintain a minimum unit thickness while honouring all available intersection points. Initial modelling was done explicitly with four weeks spent manually adjusting surfaces to align with requirements (unsuccessfully). ARANZ Geo released Leapfrog Geo’s stratigraphic sequence object type at this time, and the model was redone in less than a day (Figure 3). Further refinement was also undertaken due to errant assays and incorrect drillhole logging that could not be quantified or readily detected with an explicit approach.

**RADIAL BASIS FUNCTIONS: MAPPING THE QUICK WINS**

The use of RBF grade interpolants has become a staple of MMG’s exploration processes. Models can now be used at the initial investigation phase of a project, rather than the traditional approach of using them towards the end, after most interpretation had been completed.

**GENERATING NEW IDEAS**

For a new advanced project, an initial geometrical study of the distribution of grade is undertaken with no bias (Figure 4), allowing the RBF interpolant to simply model the strongest natural trends in the data. Often the results of this first step offers completely new ideas to the geologist and hypotheses on ore grade control can be formulated immediately. Successive refinement using observed trends as controls, form an interactive process where controlling structures are retained and refined, and data biases are recognised and removed.
COMMUNICATION

The communication implications at this stage are also major, with sometimes only a few minutes of work resulting in a product that can be shared amongst the group, with the majority of the overarching geometry clearly visible.

DRIVING DECISIONS

We use Leapfrog to effectively understand the primary properties of the deposit, possibly driving a go/no-go decision, or as a catalyst to drive further work in a targeted way. In an exploration department where so many deposits require review in a short timeframe, gaining this information and having the ability to compare our own first pass interpretation with the listed resource figures has proven invaluable.

When more than one commodity or element is required to either understand or delineate the deposit, using the same set of controls may or may not give a good representation of the primary features, giving an opportunity to pick multiple generations of mineralisation or alteration.

MMG is bringing structural geology back from being a specialist field (as often treated by the mining industry) and making it mainstream. Structural geology is heavily ingrained in the implicit modelling process, where geometrical relationships are built using overprinting rules and anisotropic trends (Figure 5). To tie any observed trends into a robust geological understanding, further fieldwork is needed for validation. The 3D geological model is no longer an end product, but part of an iterative process that undergoes rigorous testing. With the ability to easily add new data as it is acquired, implicit models have become dynamic objects that are generated to answer scientific questions rather than to be a ‘complete’ representation of a deposit. (Figure 6).

The implicit interpolation of structural surfaces is an essential part of MMG’s workflow (Figure 7), where structural measurement data are propagated throughout a defined space, and form surfaces are generated at defined intervals. This has proven an essential exercise on many projects to gain a quick interpretation of regional geometry where there is little or no sub-surface data, where such critical elements such as depth of prospective horizons can be extracted.

Formline mapping in 2D is an underutilised (and under acquired) dataset that provides the most significant...
information about geometry, and having the ability to instantly generate the equivalent surfaces in 3D has encouraged geologists to inspect their structural data more efficiently than other practices have allowed. Should a deposit be stratiform, a structural form surface is the ideal input for a heterogeneous bias.

**SPATIAL GEOCHEMISTRY**

Geochemistry has, until recently, been relatively inaccessible with geochemical classification relying on the specific skills of a geochemist who will likely remain one of a handful of people to fully utilise the findings of their study. The ioGAS link has now made Geochemistry far more accessible to other geologists. At MMG, we have found that the software partnership has acted as a gateway to encourage geologists to venture out of their comfort zone and add value to their study. Those already familiar with Leapfrog find that the ability to answer geochemical questions in real-time a good reason to begin using ioGAS in earnest, while Geochemists and those familiar with ioGAS have effectively used Leapfrog to add a far more detailed spatial element to their work (Figure 8), allowing a comparison with geophysical datasets and other modelled objects.

**RAPID IMPLICIT PROCESSES LEAD TO BETTER DECISIONS**

At MMG, working with an implicit modelling package that combines an easy-to-use and easy-to-learn interface, a rapid modelling engine, partnerships with other leading software and intuitive modelling methods have not only increased efficiency, but have caused a real expansion of skillsets for our field geologists, with structural geology, geochemistry, geophysics, and mineralisation characteristics becoming increasingly more accessible. The ability to experiment with, combine, and interpret data quickly allows far more time for us to be geologists, mapping the distribution of complex relationships, testing series of hypotheses, focussing effort on increasing critical ore-body knowledge elements, and ultimately drilling the best targets.