Recognising the impact of uncertainty in resource models

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SUMMARY

The research aimed to test the variability of geological modelling due to the interpretation bias of the person building the model. Measuring this innate uncertainty in modelling allows stakeholders to have confidence in the models, knowing the level of risk involved and being able to account for it.

New machine learning methods allow modelling scenarios to be tested in a fraction of the time of any previous modelling methods.

Using Maptek™ DomainMCF, several different possible interpretations were produced with data from the Lisheen base-metal mine in Ireland. These were compared with previous modelling using Maptek™ Vulcan™ techniques. Each model took about 10 minutes to generate, compared with one week in the past. Data from more than 100 mines was also processed using DomainMCF.

The results at Lisheen showed significant variation. The models of the main mineralised body exhibited a volumetric variation of 12% between the most optimistic prediction of the geological domains and the most pessimistic interpretations.

This is an important observation, as a variation of this magnitude will affect the resource statement. The alternative statement provides mine planners and potential investors with a quantitative assessment of the risk due to geological uncertainty.

Key words: machine learning, resource model, risk assessment

INTRODUCTION

Geological resource models are the foundation on which a mine is planned, funded and operated. It is often assumed that more data equals a better model. While this is true to a certain extent, in reality there is a cut-off point at which more drilling is effectively a waste of money.

Measuring uncertainty in resource models provides mine planners and potential investors with a quantitative assessment of risk. The sensitivity of a project to changes in geological interpretation has been neglected in the past, due to a lack of time to generate and develop different geological models.

A volumetric interpretation of geological observations is only as good as the knowledge, experience, bias and patience of the geoscientist building the model. In reality, several possible interpretations could be generated by multiple geologists.

Geological uncertainty is just as important as grade uncertainty, yet often gets overlooked, primarily because unlike grade uncertainty, there is no easy way of capturing or communicating it.

Advances in machine learning have opened up new possibilities for modelling, and this presentation outlines a new method for recognising domain uncertainty.

A case history with data from the Lisheen base metal mine in Ireland shows how several possible interpretations for geological domain boundaries were generated from the same drilling data. All solutions honour the data, highlighting the underlying uncertainty that exists in most geological settings.

Recognising that uncertainty exists is the first step towards a more realistic resource statement. The ability to measure the variation in interpretation of the resource models provides mine planners and potential investors with a quantitative assessment of risk.

The Lisheen study revealed that uncertainty can also be used as a measure to better quantify confidence when assessing resources and reserves stated compliant to the JORC code, reducing the subjectivity around the process.

Resource reports submitted in accordance with the ASX 201 JORC code must include a statement about ‘Confidence in (or conversely the uncertainty of) the geological interpretation of the mineral deposit’.

SEC rules (Dec, 2018) state that the qualified person ‘... would also be required to estimate the uncertainty associated with each class of mineral resource’.

TSX NI 43-101 guidelines include reference to ‘Discuss any significant risks and uncertainties that could reasonably be expected to affect the reliability or confidence in the exploration information, mineral resources or mineral reserve estimate, or projected economic outcomes’.

CRIRSCO 2019 International Reporting Template states that ‘...the uncertainty in the estimates should be discussed in documentation and, where material, in Public Reports’.

Using DomainMCF allows resource statements for the first time to quantitatively meet the statutory guidelines around uncertainty and risk assessment.

METHOD AND RESULTS

Lisheen case history

The Lisheen Mine, a carbonate hosted zinc-lead project located in the Irish midlands in County Tipperary was in full operation from 1999 until 2015, when it ceased production.

During that period the site used Maptek™ Vulcan™ software for underground survey, geological modelling, variography, resource estimation and mine planning.

The Lisheen data (Figure 1) was used to test how the machine learning tool performed compared to the traditional geological modelling techniques that were used during mining.

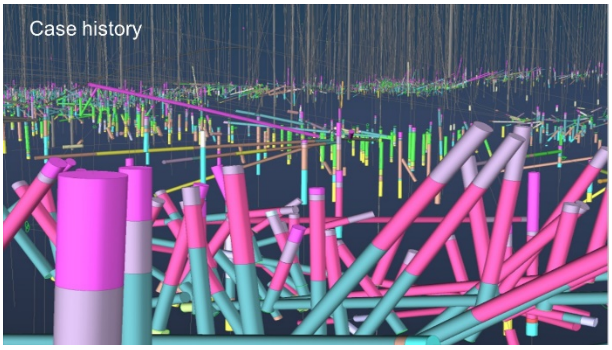

Figure 1. Complexity of drillhole data from Lisheen.

Comparing original modelling against DomainMCF predictions showed subtle differences, largely on the contact margins between ore and waste, representative of the lithological drill logging (Figure 2 and 3).

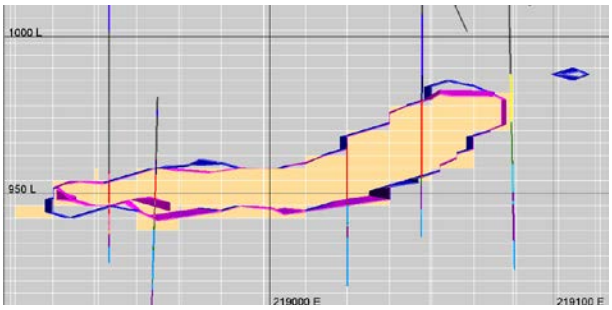

Figure 2. Cross-section through exploration drilling and wireframe outlines of two DomainMCF predictions of one Lisheen orebody, shown against a background of a third DomainMCF prediction.

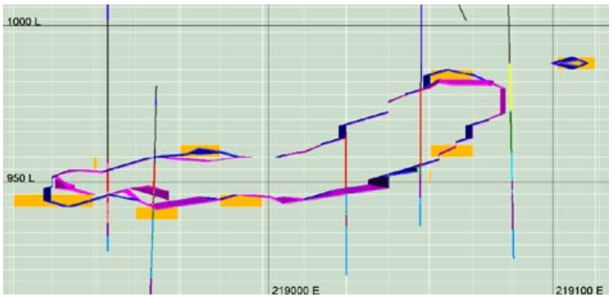

Figure 3. The two DomainMCF predictions from Figure 2 are shown against a background DomainMCF block model with spatial uncertainty in orange.

In Figure 4, a 3D perspective view of the surface drilling for the Lisheen orebody provides clues to the challenges inherent in interpretation. Even though the drilling appears closely spaced, the rapidly changing geological contacts in each hole provide a level of uncertainty as to the interpretations between adjacent drillholes.

In this deposit the majority of the geological uncertainty is related to terminal margins of the mineralised horizon.

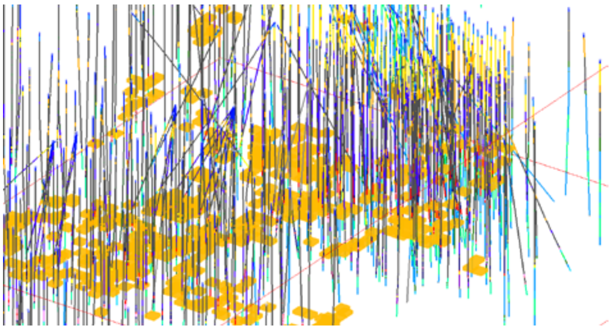

Figure 4. Yellow-orange blocks show spatial distribution of areas of uncertainty, resulting in an overall +/-6% volume variation within a suite of DomainMCF predictions.

To put the complexity of resource estimation in context of various estimation techniques employed prior to this study, setting up a single variable in a single geological domain using the inverse distance technique could entail up to 190 decisions.

Applying ordinary kriging to a single variable/domain can take up to 170 decisions in preparation alone to determine appropriate parameter settings, followed by a further potential 220 decisions to carry out the kriging estimate.

Each model generated for this case history took 10 minutes to complete using DomainMCF, compared with a week of effort by the mine geologist during the mine operation (*pers comm*, Colin Badenhorst, former Mine Geologist, Lisheen).

It is important to note that, just as different geologists' interpretation varies, the machine learning approach delivers different models. It mimics the human nature of geological interpretation by running a slightly different initial seed point each time, producing subtly different results within the boundary effect.

While there were several interpretations for the Lisheen geological domain boundaries generated from the same drilling data, all solutions honour the data. This result highlights the underlying uncertainty that exists in most geological settings that have been interpreted from subsurface data such as drilling and downhole geophysics.

The role of uncertainty

Lisheen Mine models were used to quantify volumetric uncertainty for the geological domains generated from the widely spaced exploration drillholes. Models of the main mineralised body exhibited a volumetric variation of 12% between the most optimistic prediction of the geological domains and the most pessimistic interpretations.

This is an important observation, as a variation of this magnitude will affect the resource statement. Instead of a statement such as ‘1 million tonnes at a grade of x’, the more appropriate wording would be ‘1 million tonnes (+/- 6% or +/- 60,000 tonnes) at a grade of x’.

The alternative statement provides mine planners and potential investors with a quantitative assessment of the risk due to geological uncertainty.

The consequence of getting it wrong

Without proper knowledge of the uncertainty in a model, value can often be over- or under-estimated. In a recently reported case, a $140 million dollar loss of value to the shareholders arose from over-estimation (Figure 5).

Figure 5. Graph showing an ASX listed gold mining company's loss of value.

Testing geological bias

Maptek prepared a simple, theoretical exercise to test the assumption that the same drilling data presented to different geologists would result in a wide range of geological interpretations (Figure 6).

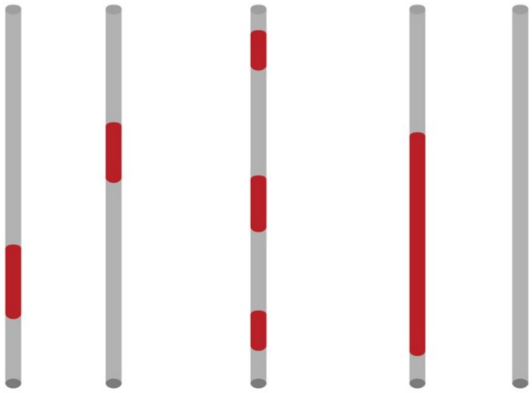

Figure 6. Drillhole schema presented to participants of geological interpretation challenge.

The exercise resulted in 20 different interpretations (Figure 7), all equally geologically valid. DomainMCF simulations produced a measurement of grade uncertainty and domain uncertainty (Figure 8).

The participants also indicated where to place an infill drillhole to improve the certainty. The results again showed a range of different suggestions (Figure 9).

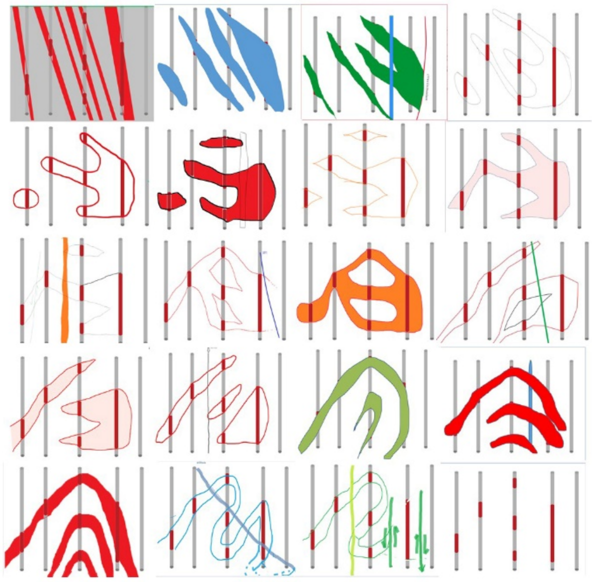

Figure 7. Different geological interpretations based on the drillhole data shown in Figure 6.

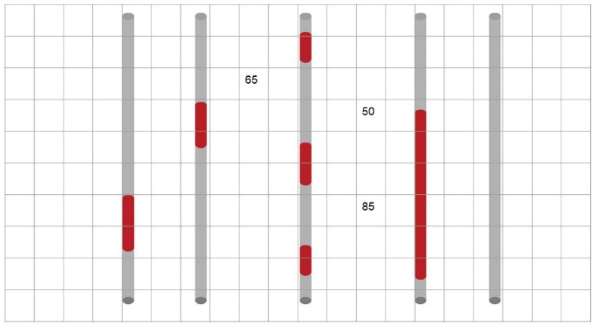

Figure 8. Domain uncertainty calculated by DomainMCF.

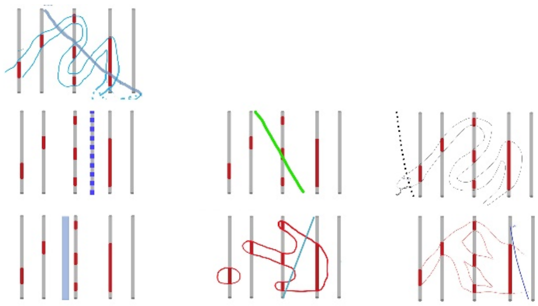

Figure 9. Different geologists proposed different infill drillholes to improve certainty.

CONCLUSIONS

DomainMCF defines domain boundaries and provides a measure of confidence in the placement of these boundaries. This machine learning approach has been thoroughly tested with a range of different types of deposits and models, including volume reconciliation, geological interpretations and uncertainty models. The results remove the subjectivity due to geological bias, giving mine planners and investors greater confidence for decision making.

ACKNOWLEDGMENTS

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REFERENCES