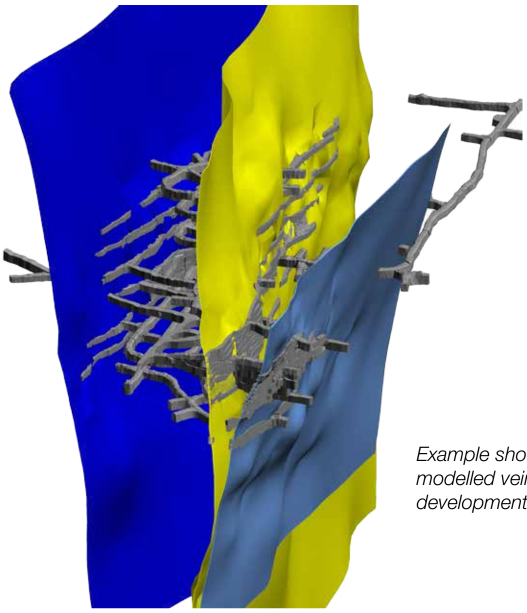
Narrow vein underground mining

Klondex Mines customised the Maptek™ Vulcan™ toolbox, using Lava scripting to create a short term modelling process for narrow vein mining, freeing up time for other work.

Klondex Mines Ltd specialises in narrow vein gold and silver deposits. It operates the Midas Mine and an ongoing bulk sampling program at the high grade Fire Creek project in Nevada. Klondex recently purchased the Rice Lake Mine in Manitoba.

In the highly dynamic environment of narrow vein mining, vein characteristics and grade can change rapidly. Local resource models rapidly become outdated as information is collected from drifting along veins. Short term modelling requires vein models to be rebuilt regularly. Monthly rebuilds fit the reconciliation and short term planning cycles, and lead to better quality resource models and long term planning.

Customising the Maptek™ Vulcan™ toolbox by linking tools into scripted workflows allows repetitive actions to be run autonomously. Lava allows panels to be written to collect the required input and provide a user friendly application.



Example showing multiple modelled veins with mine development

Background

Because veins are continuous, narrow and planar it has been difficult and time consuming to create valid final solid interpretations using traditional section-based approaches.

In addition to their planar nature, vein sets may merge and split along strike, as their development is controlled by the structural framework of their environment. In this way, vein modelling is analogous to coal seam modelling. The Vulcan GridCalc menu has extensive coal modelling options using grid modelling.

Grid modelling is a form of implicit modelling, where a grid of points is interpolated to represent an attribute of interest. Benefits of the approach in vein modelling include:

- Grid nodes between surfaces align, enabling grid maths to calculate additional attributes such as the thickness of the vein in any location and to ensure nodes do not overlap.
- Grid nodes can be extrapolated outside the actual data extents to project veins along strike or down dip.
- Grids can be output to triangulations that honour both the grid nodes and the original input vein intercepts.

The complication is that grids are modelled in plan view, which works for sub-horizontal coal deposits, but not for sub-vertical veins. The solution is to use the overall dip and dip direction of the vein to rotate the input data to a sub-horizontal plane prior to modelling.

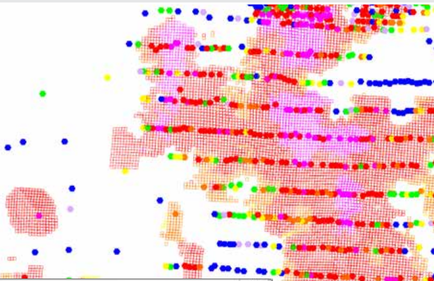
Once rotated, this data can be modelled with grids and the output triangulation rotated back to its original position. In this way, the data can be aligned to the vein orientation so the user may vary the extrapolation distance along strike and/or down dip.

Workflow

The short term modelling workflow simplifies the process from drillhole and underground channel information to a final block model that represents the vein and its spatial grade distribution, ready to be used in mine planning. The steps are as follows:

- Extract hanging wall and footwall points from drillholes and channels for the vein to be modelled.
- Rotate data to a sub-horizontal plane and model hanging wall and footwall surfaces.
- Build the vein solid and rotate data back to its original position.
- Create a block model to represent the vein solid.
- Estimate grades of economic metals into the blocks and assign confidence levels.
- Run dilution calculations to identify economic material based on minimum mining width and dilution expectations.

Using this workflow, models for active veins can be updated monthly to align with reconciliation reporting and short term planning.



Gold equivalence blocks and samples showing only blocks defined as ore once dilution calculations are taken into account

Lava scripts

Lava scripts step users through this process, starting with a specification file for settings that are to remain constant throughout the entire workflow. These settings include colours for hanging wall and footwall, dip direction and dip angle of the vein, and drillhole and channel databases to use.

User input is kept to the minimum needed to make a difference to the result, such as how far outside the data to extrapolate the models. Positive feedback is provided in the form of panels signifying completion of the running of scripts. Through Lava scripting, modelling settings and other metadata can easily be saved with the triangulations through triangulation attributes.

Lava scripting can access all Vulcan data formats such as grids, block models and Isis databases. The block model can be built without user input as the grids are interrogated for their locations and extents, supplying the required information to build the final block model on the fly.

> The Lava script does the hard work. Users spend more time validating and improving models.

The Lava scripts are set up to be adaptable to all Klondex sites. Some settings that could have been hard coded are left open for users to specify, e.g. database field names, so that the process can be transferred to a new site.

While the process uses 50% coal tools, the Lava panel terminology is specific to vein modelling. Lava scripting enables creation of tools that are specific to the work.

The entire process is quick and simple. Users can go from a set of drillholes with some coded veins through to a first pass analysis of defined ore zones or areas identified for further drilling in less than an hour. Manually, this might involve 100 or more steps and would take many hours.

Additional functionality

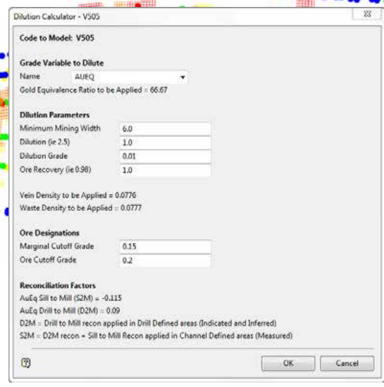
Typically, in high grade epithermal vein deposits, drilling may under-represent the high grade ore shoots and hence the metal attained once silling has been undertaken. This can lead to areas not being mined that may in fact be economic if silling were undertaken.

The workflow enables drillhole data and underground channel sample datasets to be easily turned on or off, so models can be created to represent both pre-mining and post-mining results. Understanding the historical performance of ore shoots and the factors that affected their mining performance can aid future planning and analysis of ore shoots that are currently only drill defined.

As infill drilling is undertaken, the metal and economic zones of an ore shoot may change significantly. The scripted workflow enables new drilling to be quickly incorporated in updated models. This allows the results of drilling programs to be measured and aids planning of new infill programs.

A block model without waste blocks is quicker to create and much smaller than a full block model. It can be useful in the early stages of planning to identify diluted ore and waste zones. However, waste blocks are needed for short term planning and for Stope Optimiser output, where the reporting of diluted tonnage and grade from many triangulations is critical.

The ability to run dilution calculations directly on the output block models enables geologists to quickly answer the questions of 'where is the economic mineralisation' and 'what material is marginal' with the current assumptions. This functionality acts as an early stage planning tool prior to the use of Stope Optimiser at the engineering stage.



Vulcan Lava script panel for dilution calculations, providing a simple interface for user settings

> Lava scripting simplifies the process to the key steps, so users validate the results of each step before they move to the next.

Outcomes

Klondex combined tools from different menu options into a standardised workflow, simplifying what would otherwise be a complex task. Block modelling and triangulation naming is standardised, so when geologists pass models on to the engineers they know exactly what they will be working with.

Site geologists are able to concentrate on the real inputs required and spend more time validating the results, rather than just concentrating on generating the vein triangulation. By adding the tools to build block models, perform estimates, and run dilution calculations, site personnel take greater ownership of the results and how they affect short term planning. Importantly, they also have the appropriate tools and more time to allow them to identify new opportunities.

Thanks to
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