# From paper to bytes – digital mapping implementation

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## ABSTRACT

The use of photogrammetry has greatly increased the accuracy of 3D mapping underground. However, this has not reduced the need or desire for geologists to produce plans and sections showing an interpretation of the mapped geology. At the Waihi Underground Gold Mine, a hybrid solution has been developed that utilises the accuracy of photogrammetry and mapping onto face photos with the CAD-based Deswik.Mapping™ functions to create plan and section maps. These have the benefit of looking like traditional paper maps but are more spatially accurate and richly attributed with metadata that can be filtered and exported to downstream processes. Deswik.Mapping™ is a tablet-based solution that allows the geologist to map digitally with a stylus. Automation is utilised for the updating of survey as-builts, approved designs, drill holes, geological mapping, vein interpretations and mine work areas, reducing the requirement to print out maps at various locations and scales. Having 3D mine software on a tablet device provides a wealth of features not available when using paper: scaling is a problem of the past; information can be turned on and off; features can be viewed in 3D; and measurements between points of interest can be calculated in 3D space, for example, between vein wireframes and drill hole sample information. A suite of custom scripts has been developed that take the spatially accurate, registered and attributed polyline data from photogrammetry scans and converts them to a geological mapping legend with vein textures, structural information, and lithological boundaries. These 3D maps can be plotted in plan or section view and satisfy the requirements of the most ardent paper map supporter.

## INTRODUCTION

Mapping is a fundamental skill for a geologist and is taught at all levels of an undergraduate geology degree. Producing a quality geological map is often one of the first tasks undertaken to build a picture of sub surface geology and underpins the lithological, structural and geochemical model of an area of interest. Surface mapping was traditionally done on paper using a compass and topographical map, but now routinely utilises GIS programs with GPS capability to create detailed maps with attributed layers. Smartphone applications exist that can take outcrop strike and dip measurements with photos and comments, all spatially located using GPS. Creating maps for a geologist has never been easier.

However, many underground mines still use paper face mapping sheets and back maps printed from the digital master copies (Doyle and Whaanga, 2017). At the Waihi underground gold mine photogrammetry has now replaced paper face mapping sheets. Reviewing the current face position against the interpreted vein direction with associated drill hole and level information is crucial for an underground geologist to make an informed decision as to the direction of the next cut. The last piece of the mapping puzzle to solve was the requirement to map areas not covered by photogrammetry and to add detail to a traditional 2D back map.

## GEOLOGICAL SETTING

The Hauraki Goldfield comprises approximately fifty epithermal deposits (Braithwaite and McKay, 1989) and lies within a NNE-trending Miocene to Pliocene calc-alkaline arc (the Coromandel Volcanic Zone). Gold mineralisation is localised within moderately to steeply dipping quartz veining, breccias and vein stockworking.

## HISTORY OF MINING IN WAIHI

Gold was first discovered near Coromandel township in 1852 but economic gold was not discovered in the Waihi area until 1878. Mining operations were transferred to the Waihi Gold Mining Co. in 1890 and mining activity continued until the close of the mine in 1952. During this time, ~5.5 Moz Au and 38.4 Moz Ag (McAra, 1988) were extracted (~174 t Au and 1193 t Ag). Operations recommenced in 1988 with the opening of the Martha open pit mine. Underground operations at Favona began in early 2005 and several additional orebodies have since been identified and mined. More than 3.2 Moz Au have been extracted by the combined open pit and underground operations since mining recommenced in 1988.

# MAPPING PROCESS

## Deswik.Mapping™ project set-up

A master geological mapping project is set-up in Deswik.CAD with mapping configured as shown in (Figure 1). Through extensive customisation options, features such as colours, line types, custom feature symbols and structural information can be set-up to represent any aspect of mapping, including classic lithological mapping, hydro-geological, and geotechnical mapping.

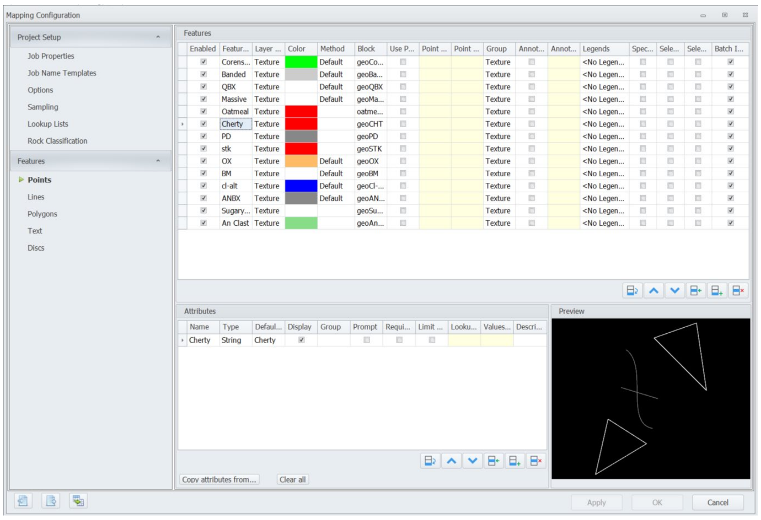


**FIG 1** – Mapping configuration screen with custom draw feature symbology.

The master mapping project exists on a surface file server into which daily mapping is imported from different sources, validated, attributed, and integrated. Reference layers in the project are used to assist with entering mapping, including survey as built files, diamond drilling, and face chips. When drives and continuous mapping are imported, an incrementally updated ore drive map of the mine is created. This is then utilised by those in the technical services department, who create dynamic links from their own templates and master files. The geology mapping data are automatically updated on an overnight schedule or can be reloaded manually.

## Underground tablet set-up

A geology mapping template is set-up with the same reference layers as the master mapping project. This template is kept as minimal as possible to reduce file sizes and load times. As with the master mapping project, this template is backed up each night and automatically updated on the surface file servers. Final mapping completed in the master mapping project is updated in this template so the geologist begins the day underground with the updated drive mapping and survey as builts from the previous shift, ensuring that everyone has the latest data available to inform their work.

### *Plane definition set-up*

A plane definition is a CAD concept that is used to save a custom view of an area to be mapped. It can be thought of like a 3D bookmark. The geologist opens the template on a desktop computer and moves the centre point of a working plane to the next portion of the orebody along strike, fixing the elevation to the new back height. Plane definitions exist for all active ore drives and are updated as required. This replaces the act of shuffling multiple maps in a mapping folder and is similar to a scaled paper map process with surveyed laser points (Doyle and Whaanga, 2017).

A plane definition contains a default layer pre-set with specific reference information displayed in a precise manner. Vein wireframes are clipped at the plane height. Existing mapping only contains the mapped vein outlines, drill holes, and survey lasers and as builts for spatial location. However, multiple layer pre-sets exist that can be turned on to view reference data that provide insight into geological and grade continuity. When it is time to spatially locate the current face and input vein information, the reference data can be removed leaving an uncluttered workspace to draw on. This is vastly improved from the use of paper where all data are static and a balance must be struck with providing enough information and having space to draw and annotate. In addition, data on the tablet can be rotated in three dimensions to line up vein positions along dip and strike.

### *Create new job*

Prior to heading underground, the ore control geologist opens Deswik.Mapping$^{TM}$ on the tablet and creates a new job with the current day as the job name. The updated and refreshed geology template is used as the base project and is saved locally on the tablet along with all the drill hole information (Figure 2).


**FIG 2** – Plan view geology mapping template on a tablet showing veins (red), andesite host rock (green), diamond drill holes (grey), modelled vein positions (blue), approved design boundaries (dashed red), approved design centrelines (white).

## Ore drive mapping with Metashape

Face and back mapping lines and symbology are sketched directly on to photos with the photogrammetry software Metashape (Whaanga, Vigour-Brown and Nowland, 2019). An example of a mapped and annotated face is shown in Figure 3. As this data are spatially located through surveyed points, there is no requirement to manually sketch this into Deswik.Mapping$^{TM}$.

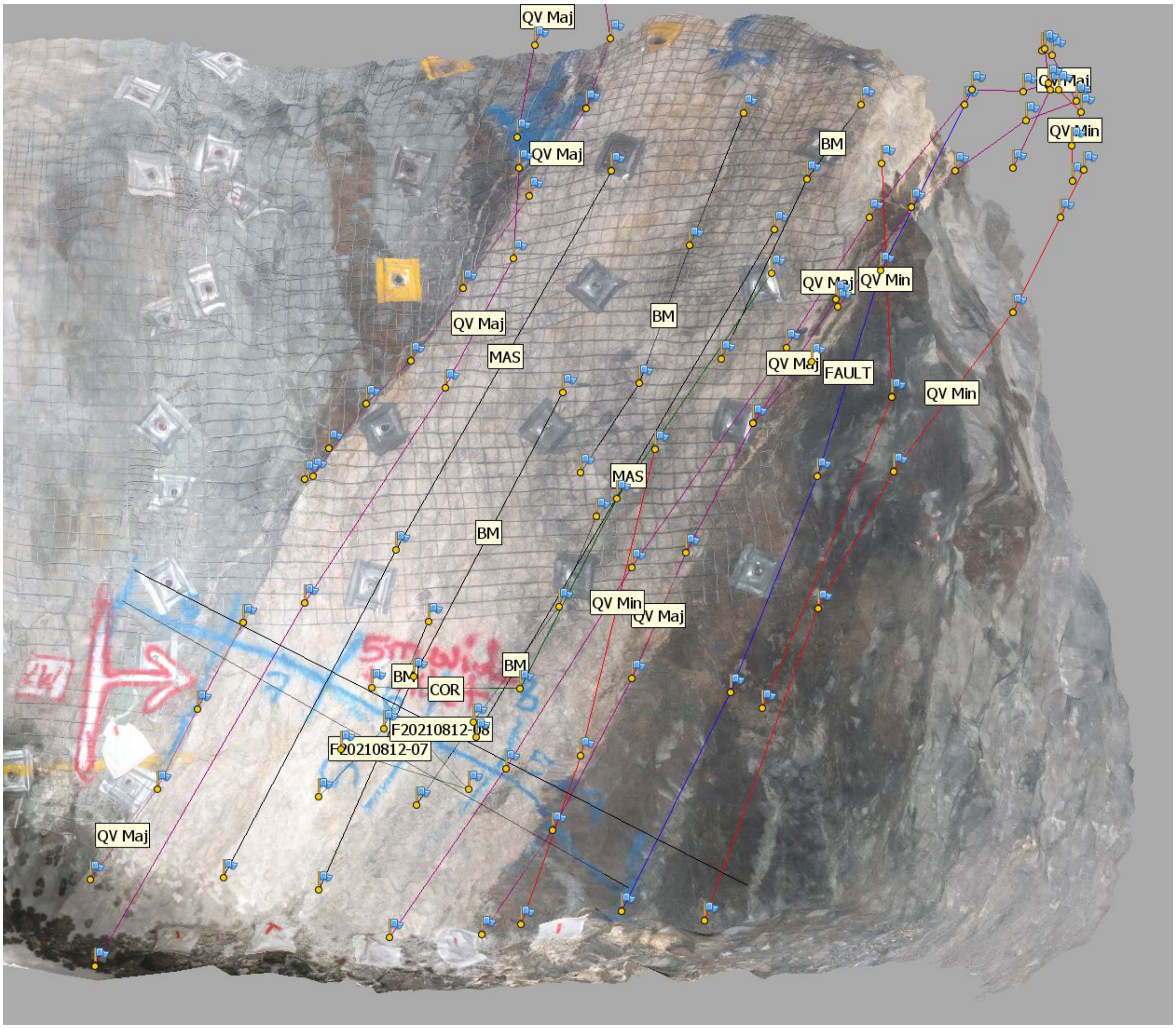


**FIG 3** – Underground face (REX5 F20210812–07) in Metashape showing sketched vein contacts (red and pink), faults (blue), textural and lithological features (black).

### *Process maps*

Process maps is the Deswik scripting tool, allowing customisation of repetitive tasks. Sketched vein information is attributed in Metashape with a duplicate legend that exists in Deswik.Mapping™. Once this has been spatially referenced through the photogrammetry process the data are exported from Metashape and imported to Deswik.Mapping™, automatically creating completed ore drive mapping in three dimensions, with vein texture, type and lithology symbology converted in one step (Figures 4 and 5).

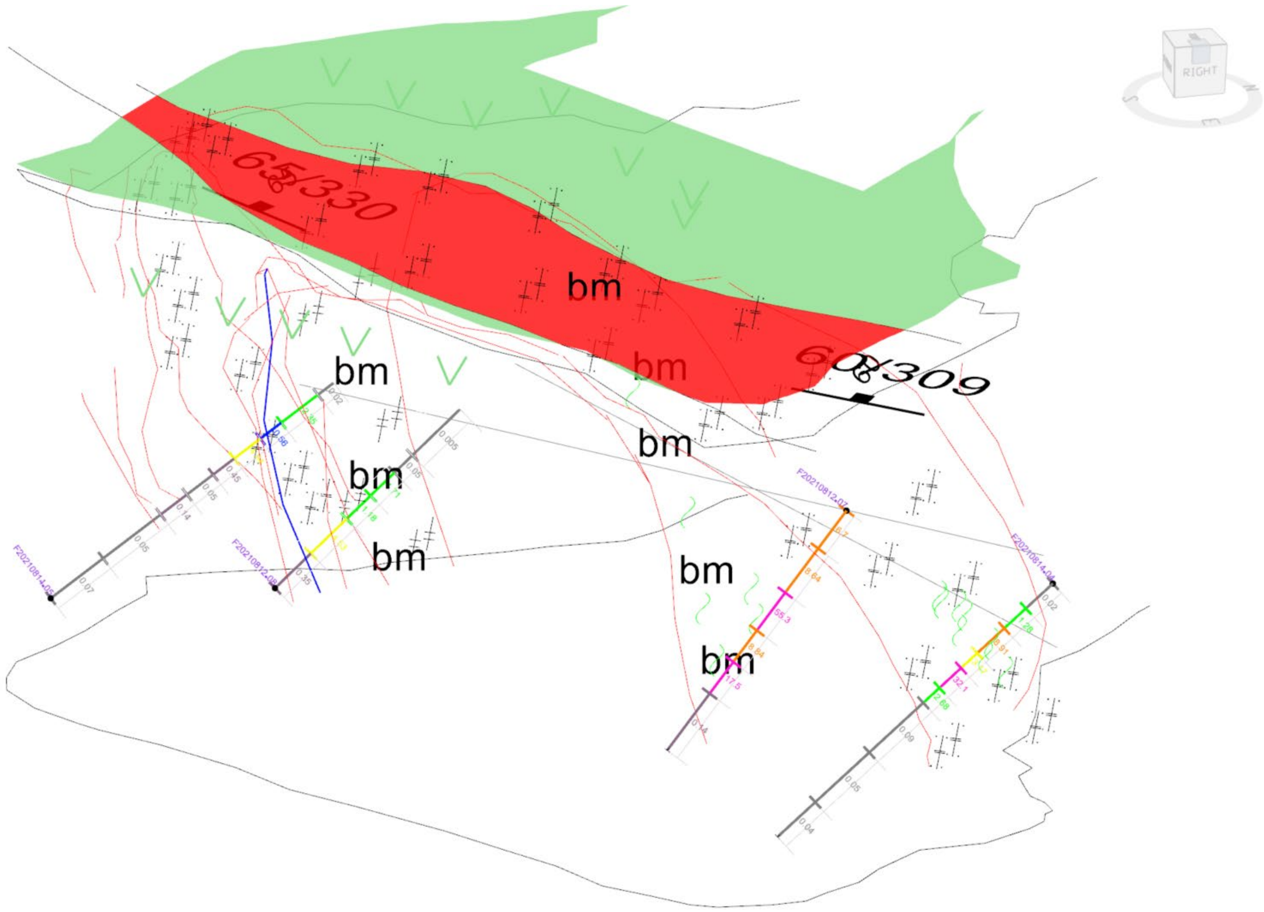


**FIG 4** – Imported mapping showing channels, orebody (red), lithology (green), veining (red) and structural measurements.

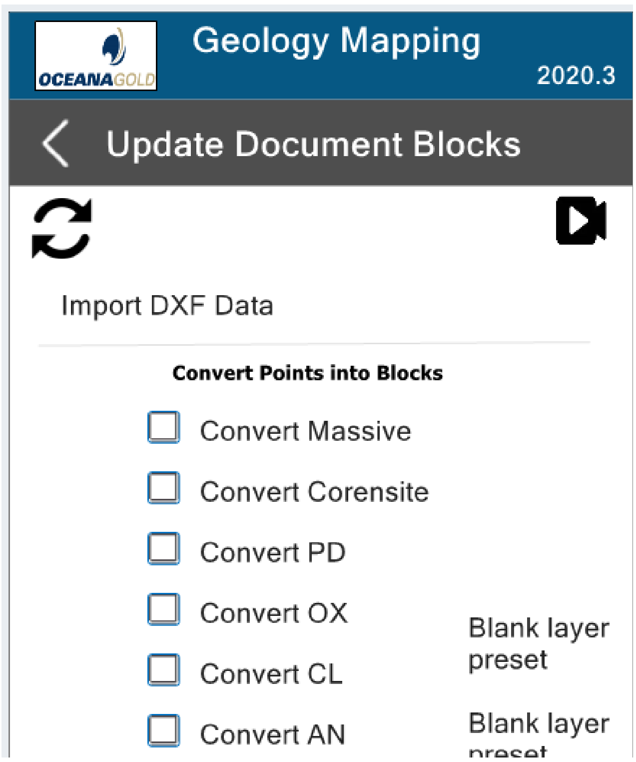


**FIG 5** – Deswik.Mapping$^{TM}$ process map.

Previously, interpreted sketch data had to be manually transferred from paper mapping to either a master level plan or digital surface map, effectively duplicating the underground mapping task on the surface. With the new process the mapping is completed at the face onto digital photos and is automatically transferred into the master map, greatly reducing the time from hours to minutes whilst increasing spatial accuracy.

## Mapping with Deswik.Mapping$^{TM}$

Photogrammetry and survey pick-ups are not required for every face. In the absence of these the approximate spatial position of a face can be calculated from survey lasers and offsets, and mapping completed manually.

### *Working plane creation*

A face section view can be created and oriented in Deswik.Mapping$^{TM}$ using distances measured at the face. The distance from a known survey laser, an offset to the left or right side of face, face width and azimuth are all that is required to locate a face position using the 'face from laser line' function (Figure 6).

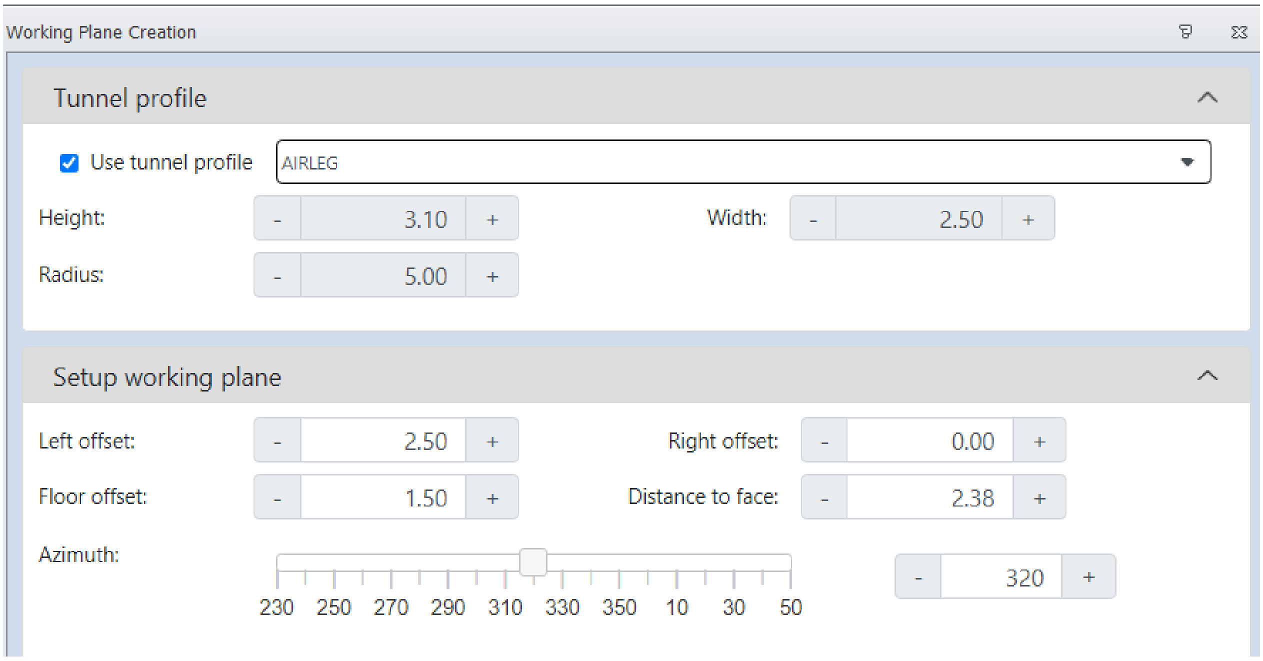


**FIG 6** – Working plane creation process in Deswik.Mapping$^{TM}$.

The back outline of the drive and any other geological information are sketched in plan view. The face can also be sketched in two dimensions using the working plane.

### *Structural and vein measurements*

Vein orientation information is entered at this point with a measurement of the main mineralised veins as a minimum. Any fault and shear information with orientations can be entered and these attributes customised in the template. These measurements help to ensure that the face mark-up and ore drive direction are correct.

## MAPPING SYNCHRONISATION

The geology master project contains a validated and clean version of the geology mapping template and is dynamically linked to the engineering, survey and geotechnical departments' master files. A master set of current geology, vein and structural wireframes is also contained in this project for use by the technical services department.

The geology mapping project contains reference data as well as all validated and unvalidated mapping information. This project exists on the server and is used to import, update and clean up mapping data from both Metashape and Deswik.Mapping$^{TM}$.

The geology mapping template refreshes overnight from the geology mapping project and is the base template used for mapping underground. Plane definitions are created and kept up to date in this project for spatial location underground.

The daily tablet job is created using the geology mapping template to map areas not covered by photogrammetry and to input orientation data. This project is synchronised using a process map that merges all daily mapping data into the geology mapping project.

Any data created in Metashape is imported via a.dxf and merged with the geology mapping project.

The tablet job is independent of the ore mapping process so multiple geologists can map different areas using several tablets underground whilst another geologist is updating and validating ore drive mapping from Metashape on the surface.

Once the data are checked and validated the Geology master project can be refreshed and mapping is available for other departments to use.

The flow chart in Figure 7 illustrates the interaction between the different components of the process.

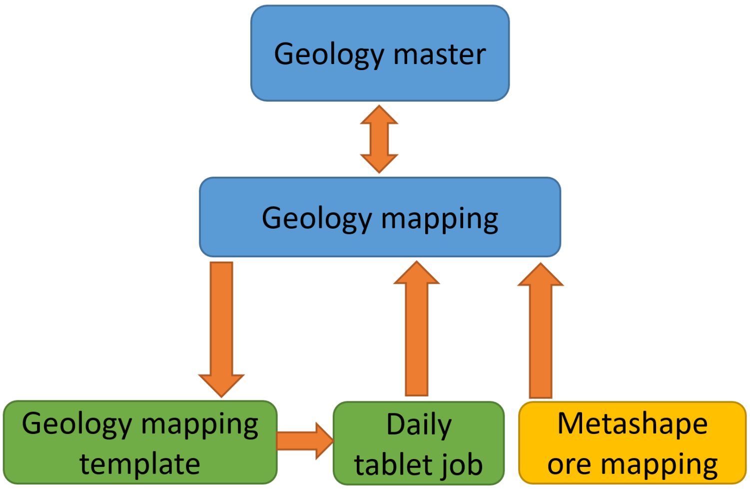


**FIG 7** – The different components of the digital mapping process.

## MAPPING OUTPUTS

Deswik.Mapping™ has excellent plotting functions. As the data exists in 3D, maps of any shape, size or orientation can be generated, from A0 level plans through to individual face sections. Structural data has vein domain information and is spatially located and can be analysed as a stereonet in structural programs. All vein linework is imported into Leapfrog software and, along with interval selection of channels, creates detailed vein wireframes. Mapping is reviewed against planned drive outlines and rolling schedules and utilised as a discussion point at weekly planning meetings for short interval control.

## EVALUATION OF DIGITAL MAPPING PROCESS

### Advantages

There are many positive aspects of using digital mapping at Waihi:

- It is spatially more accurate than traditional paper mapping, increasing the quality of work.
- It saves geologists time whilst mapping underground as well as during the data processing phase, as data entry only occurs once.
- It allows the ability to review mapping from 3D scans and re-map areas when required. This is particularly useful when faces are obscured by fibre/shotcrete or otherwise inaccessible, or when a face is unable to be mapped before the cut is taken.
- Tough computer tablets are more waterproof than paper.

- It provides geologists with a wealth of additional 3D information in an easily useable format that is not possible with paper mapping. This information can be used to better inform drive direction decisions.

## Limitations

Digital mapping does have some disadvantages:

- Tablet hardware limitations mean that manipulation of large amounts of data are not possible, so a balance must be found between having all the available data and tablet speed.
- There is a steep learning curve to using a digital device underground. Familiarity with paper mapping requires a re-learning process, with similar tasks being completed in different manner.
- Sketching on a tablet is typically slower than drawing on a paper map.
- Unlike digital devices, paper is always available and does not crash or require a network connection to transfer data.

# CONCLUSIONS

Customising digital mapping offerings to integrate into existing production workflows at the Waihi underground gold mine has had a number of positive impacts, including time savings and increased data quality. It has enabled geologists to utilise a larger amount of 3D information, ultimately creating greater confidence and accuracy in the ore control direction process. Although there are some limitations associated with the digital mapping process, these are far outweighed by the benefits.

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