



AN UNDERGROUND MAPPING TO IMPLICIT MODELING WORKFLOW

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AN UNDERGROUND MAPPING TO IMPLICIT MODELING WORKFLOW

In mining geology, robust mine mapping and interpretation of ore-controlling features are important to reduce risk associated with geological uncertainty and ensure that ore value and mining operational revenue are maximized.

Improved accuracy and efficiency of the ore control process, as well as increasing orebody knowledge has downstream effects leading to a more informed resource model. In an underground mine, this can also help improve development and stope planning, as well as drill targeting.

In the not so distant past, underground mapping has been drawn on paper, neaten up in the office, maybe scanned, and possibly digitized in a 3D environment to create explicit 3D meshes. Sometimes it's just left in a folder! Paper-based mine geology methods and physical modeling techniques need to be updated for the age of the digital 3D mine. Two tools at the forefront of this are Seequent's Leapfrog Geo software as well as Deswik.Mapping.

Deswik's GeoTools portfolio is designed for mine geologists to improve efficiency by eliminating the double handling of data. Geologists can bring their designs, photography, and sample data into their 3D mine design environment and capture their observations directly in 3D space. If a site is using Deswik for other actions such as design and survey, data transfer between disciplines becomes seamless and automatic such that geologists always have the latest design and as-built information at their fingertips.

Seequent's Leapfrog Geo software is a workflow-based 3D geological modeling tool. Leapfrog Geo's advanced implicit modeling engine bypasses time-consuming wireframing and lets you build models directly from various sources including drillholes, points and surfaces. Models update dynamically when new data is added to a project, making it easy to keep models current. This reduces the risk of making key decisions based on out-of-date information.

The following workflow demonstrates how you can create a robust geological map of your underground mine using Deswik.Mapping and use this to inform your implicit Leapfrog Geological Model. Pairing Seequent's Leapfrog Geo and Deswik.Mapping creates an industry-leading workflow for smarter mining.

Underground Geological Mapping

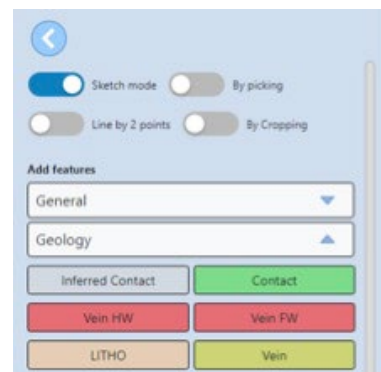
Deswik.Mapping is a Windows tablet app that allows geologists to create geological maps and photography while offline and underground. Users can establish their location in 3D space, using survey markers and tunnel design, before they begin the mapping process. Photographs can be overlaid with geological mapping, to create a rich representation of the geology being mapped. The geological mapping work can then be imported in Deswik.CAD and made available for other users to view and use within their 3D mine design environment.



To begin this example, from Deswik.Mapping we open the relevant level, and create a new Face section to map. Deswik.Mapping is configurable to every site and as such the features available to draw can be specific to each site. For this example, we have configured a vein hangingwall and footwall feature, both of which prompt users to specify which lode the HW/FW belongs to.

Sketching contacts

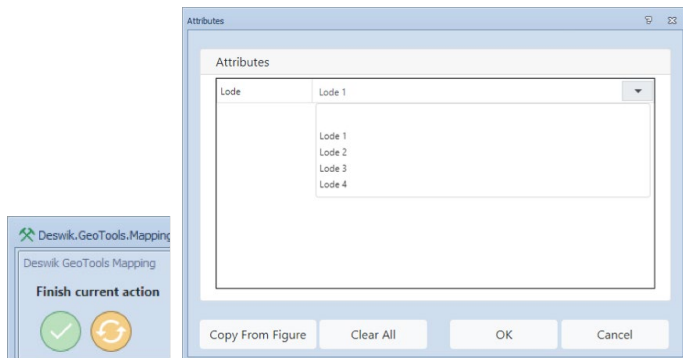
After the face is setup, go into the **Drawing Tools** menu, turn on the **Sketch** mode toggle, then tap the **Vein HW** button.



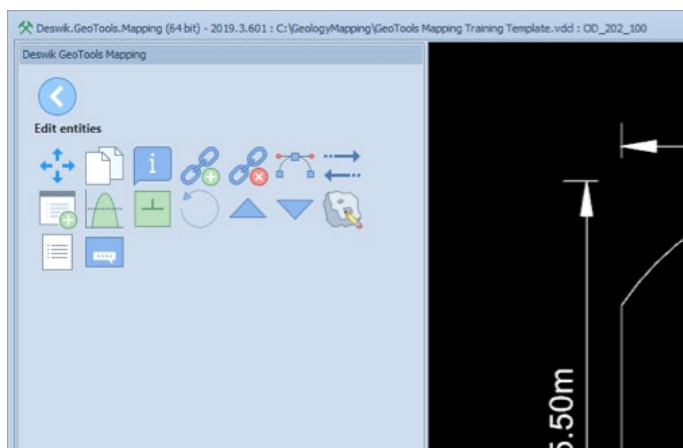
Using your tablet's stylus, draw the hanging wall of lode on the screen.

Tip When sketching and you want to finish a line segment, lift the stylus off the screen a tiny amount, then tap at the end of the line – like writing a full stop! This stops sketching the current segment.

Tap the Finish button to end sketching, and select enter **Lode 1** as the lode when prompted.

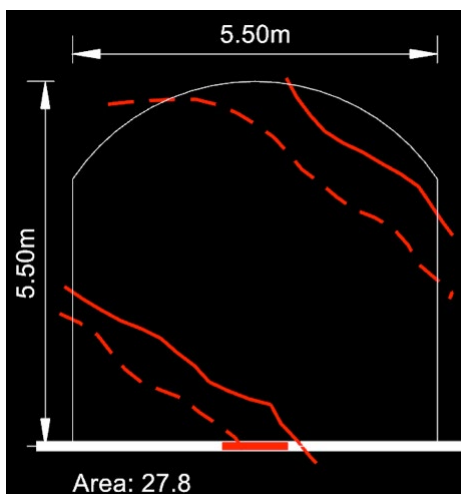


The Lode 1 hangingwall is now on screen, in its 3D position.



Use the same process to sketch on the footwall contact of load 1, using the **Vein FW** feature, making sure to select **Lode 1** when prompted.

Repeat the process to digitize other lodes – in this case, we digitize a second lode, making sure to set the HW and FW to Lode 2 when prompted.

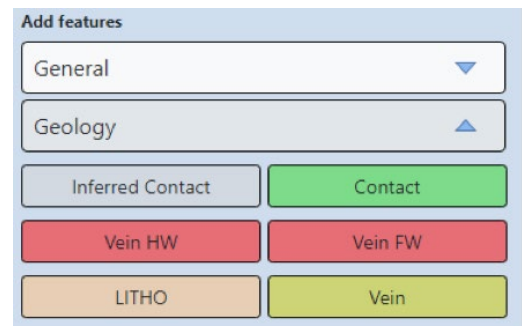


Creating polygons

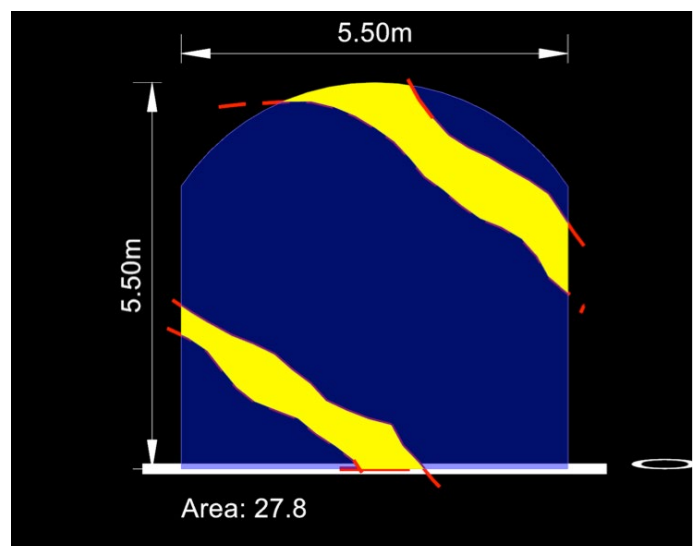
After the veins are digitized, create polygons between the contacts to make the geology apparent in the drawing. The fastest tool for this task is called 'picking' – somewhat similar to the 'flood fill' action in Paint.

In the drawing tools menu, turn on the **By Picking** toggle

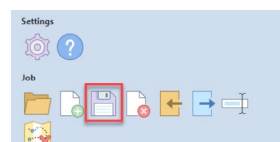
☒ By picking then select the Vein feature under the Geology features:



Tap the stylus inside the vein, and some hatching will appear to indicate the area you selected. You can digitize multiple polygons, so go ahead and tap in the second vein too, and then tap the finish button. Next, we want to define the host rock, so with the picking option still toggled, tap the **Litho** button, then tap in the space above Lode 1, then between the veins, then below vein two, then tap finish. You will be prompted to select a lithology code for the host rock – select M2. The screen will redraw and you will see a very typical looking face map.



Save the current document in the mapping app from the home menu:

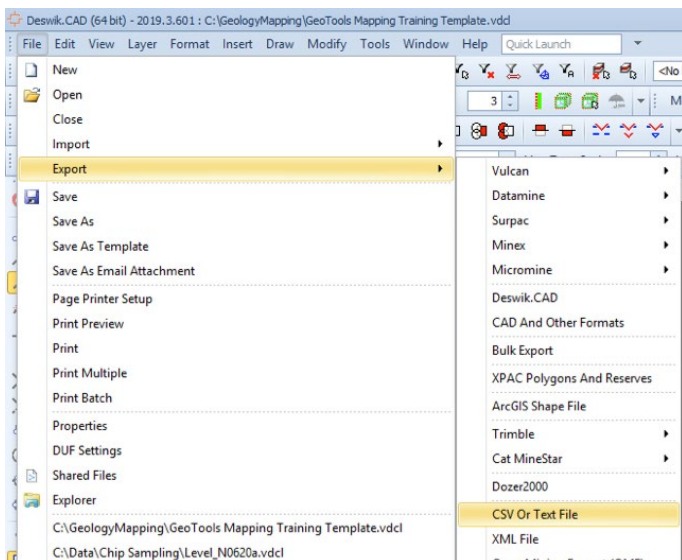


Exporting Data

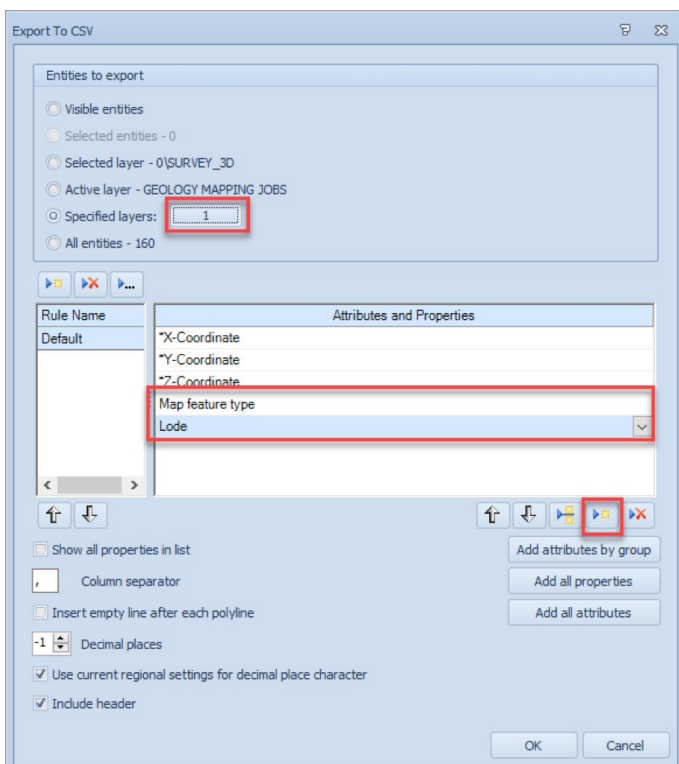
To model the vein in Leapfrog Geo we first need to export the vein data from **Deswik.CAD**.

Open **Deswik.CAD**, then open the mapping document where the veins were created.

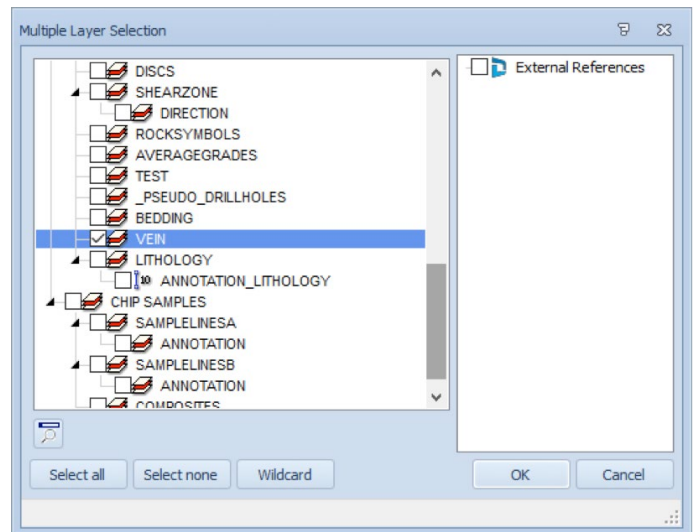
To export the vein data, select: **File | Export | CSV or Text file**.




The **Export to CSV** dialog box appears. In the **Entities to Export** section, we need to specify the layer in the CAD document that stores the veins. In this case, select the **Specified layers** radio button, then click the button to the right of the radio button.



When prompted to select a layer from the list to export, scroll down to the layer called **VEIN** and click **OK**.



Next, you must select the attributes (data) to export with the veins. Just below the **Attributes and properties** table, click  to add a new record to the table. In the table, select the new cell and choose **Map Feature Type** from the list. Add another row and select **Lode** from the list.

Click OK to display a Save As dialog box. Enter the name of the file destination – name the file **Veins.csv**.

This will create a CSV file of the vein polylines, with the associated data, which in this case is the lode name and whether the feature is a footwall or hanging wall.

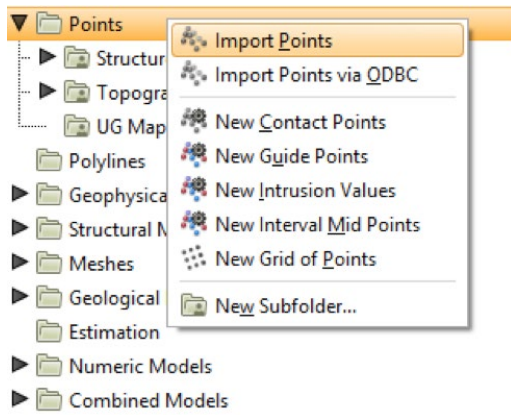
	A	B	C	D	E
1	*X-Coordinate	*Y-Coordinate	*Z-Coordinate	LODE	Map feature type
2	9540.776413	50913.12201	3741.166043	LODE 1	Vein HW
3	9540.561576	50913.05831	3741.118036	LODE 1	Vein HW
4	9540.35538	50912.99649	3741.039428	LODE 1	Vein HW
5	9540.154868	50912.93603	3740.946386	LODE 1	Vein HW
6	9539.955516	50912.87586	3740.850702	LODE 1	Vein HW
7	9539.757487	50912.81601	3740.752114	LODE 1	Vein HW
8	9539.568077	50912.75832	3740.636729	LODE 1	Vein HW
9	9539.383248	50912.70181	3740.513593	LODE 1	Vein HW
10	9539.193321	50912.644	3740.399126	LODE 1	Vein HW
11	9539.011795	50912.58835	3740.270797	LODE 1	Vein HW
12	9538.835055	50912.53394	3740.135442	LODE 1	Vein HW
13	9538.667269	50912.48191	3739.988277	LODE 1	Vein HW
14	9538.497137	50912.42925	3739.844057	LODE 1	Vein HW
15	9538.319515	50912.37462	3739.709956	LODE 1	Vein HW
16	9538.156124	50912.32376	3739.557529	LODE 1	Vein HW
17	9537.978283	50912.26907	3739.423743	LODE 1	Vein HW
18	9537.792124	50912.21221	3739.302788	LODE 1	Vein HW

Underground Geological Modeling

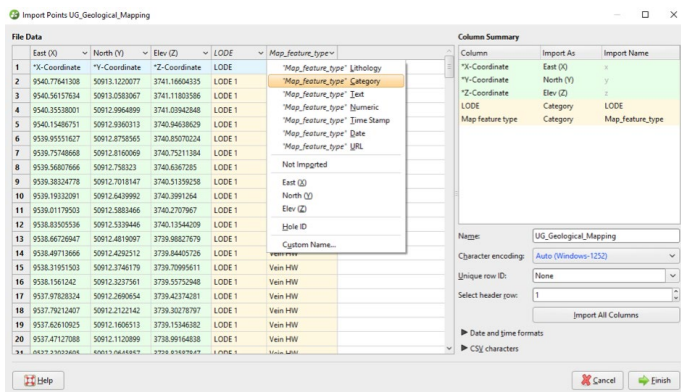
With Leapfrog Geo, you can rapidly build complex underground geological models from drillhole data, structural data, points, polylines, and meshes in the project. Leapfrog Geo's powerful implicit modeling engine and unrivalled processing power can use millions of points. Here, we will be using the geological mapping conducted above in Deswik.Mapping to update a series of vein meshes in Leapfrog Geo.

The exported data can be imported into Leapfrog Geo as points.

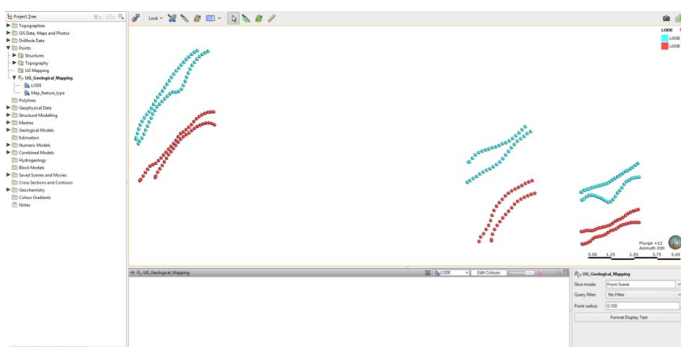
Right-click **Points | Import Points**



When the data is imported the Lode and Map Feature columns can be imported as categories. Using the drop-down menu, attributes can be assigned an **Import As** type of **Category**.

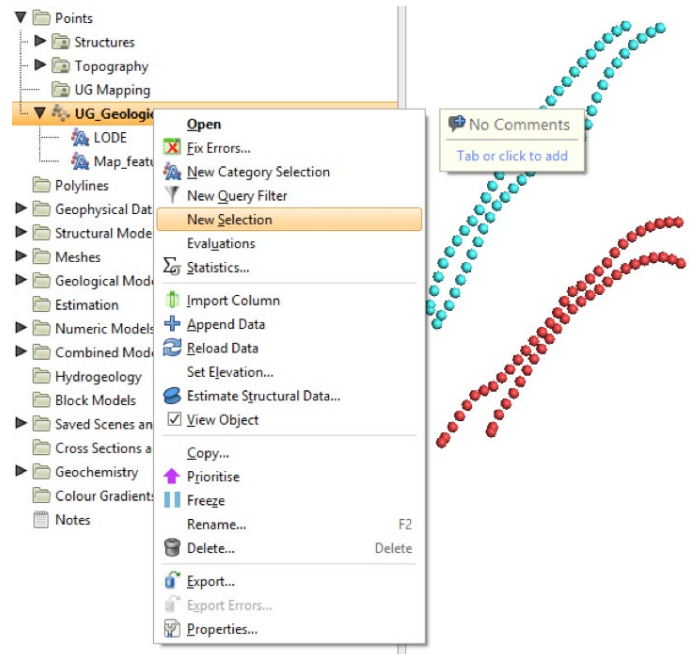


When imported, you can view the underground mapping by dragging the points into the 3D scene from the Project Tree. The drop-down display can be toggled to view the assigned Lode as well as whether the map feature is HW or FW.

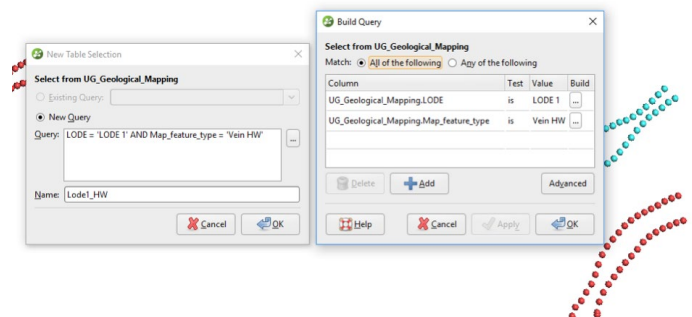


Next, we will create a series of new selections, allowing for the extraction of subsets of points. This will allow each geological feature to be modeled separately.

Right-click the Underground Mapping points and then click **New Selection**.

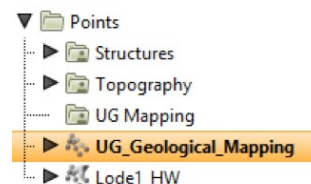


Click **...** to build a query. In this first example, we want to create a query for extracting just the HW points for Lode 1.

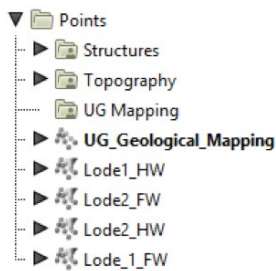


Click **OK**.

This will create another object in the Project Tree for the selected points.



For veins, the HW and FW of each lode need to be independently extracted. Repeat the above process for each HW and FW.

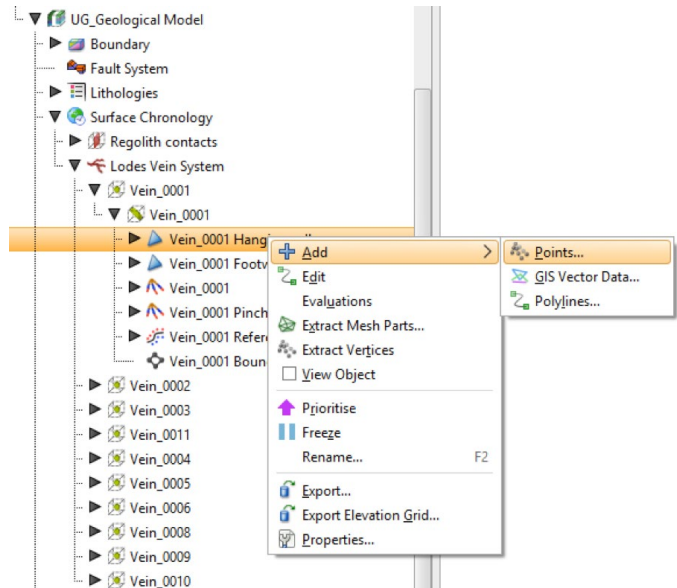


In Leapfrog Geo, a vein is a type of contact surface which crosscuts and removes existing lithologies and replaces them with the vein lithology inside the boundary defined by the HW and FW surfaces. These HW and FW surfaces are constructed from selected input data and can be refined independently of one another to include additional data such as mapping points.

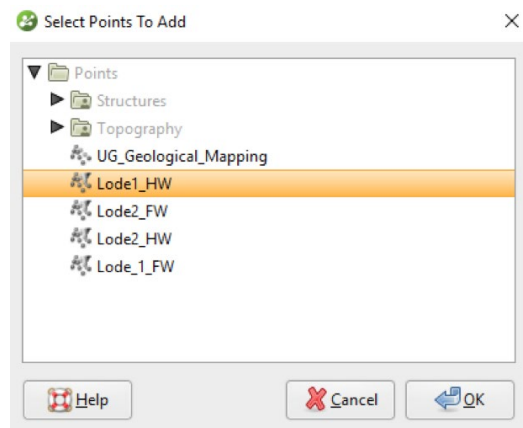
In your geological model, you will have a series of veins modelled from selected assay and geological intervals from your drilling. We can now add our mapping data to the hanging wall and footwall veins to ensure our meshes are made from the latest geological information.

Under the Surface Chronology, expand the project tree of Vein 1 to find the Hanging Wall surface.

Right-click the Hanging Wall and then click **Add | Points**.

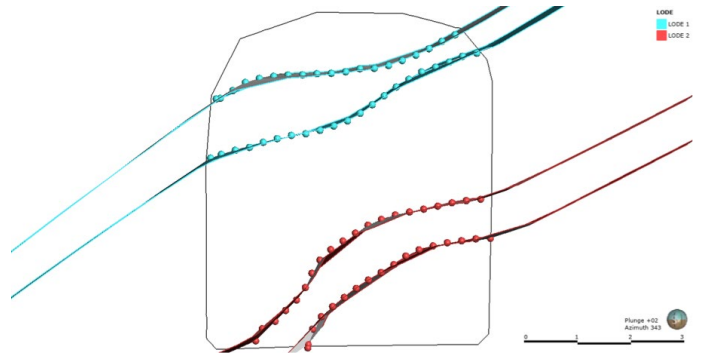


Select the filtered Vein 1 HW points.



The modeling will dynamically update to incorporate the mapped points as well as any previously included drilling.

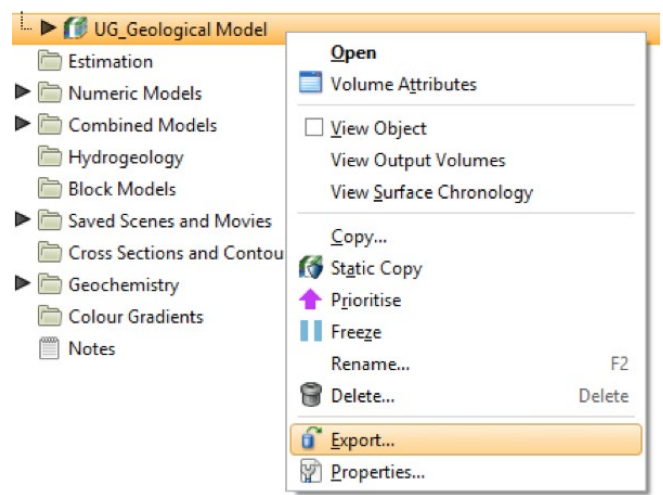
Repeat this process for the footwall surface and for any other vein or geological feature.



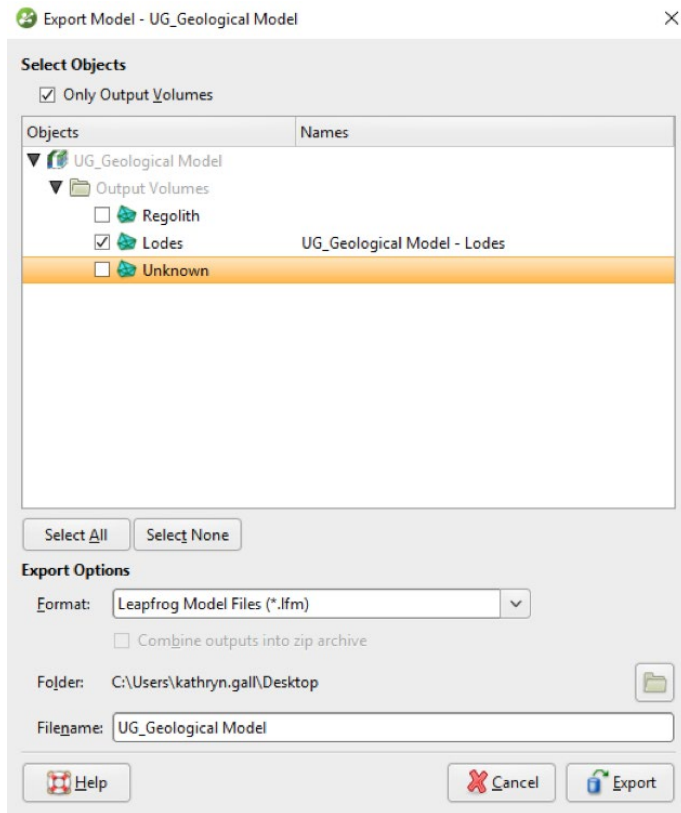
You will now have an implicit model of your underground veins.

To take this information back to Deswik, you can export the output volumes from Leapfrog.

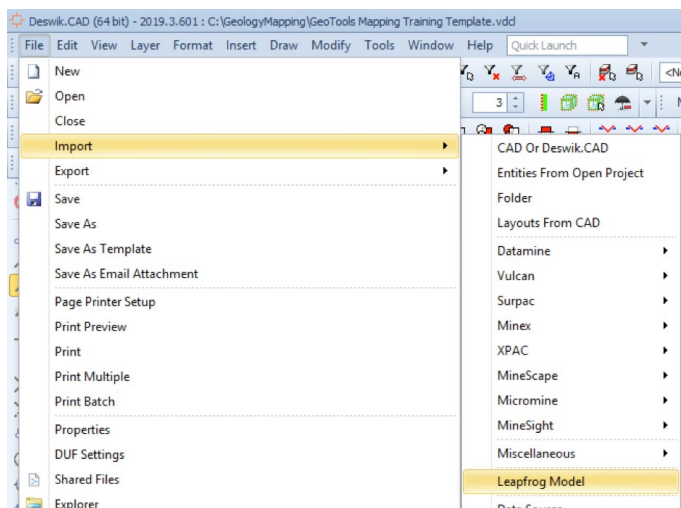
Right-click the Geological Model Header in the project tree and then click **Export**.



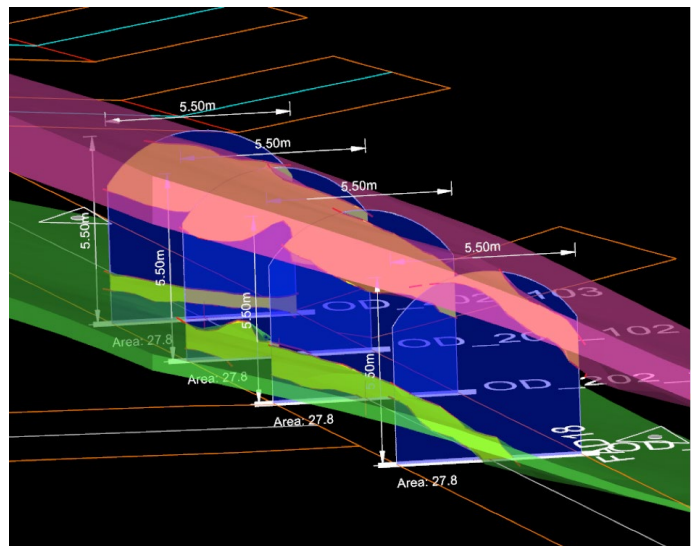
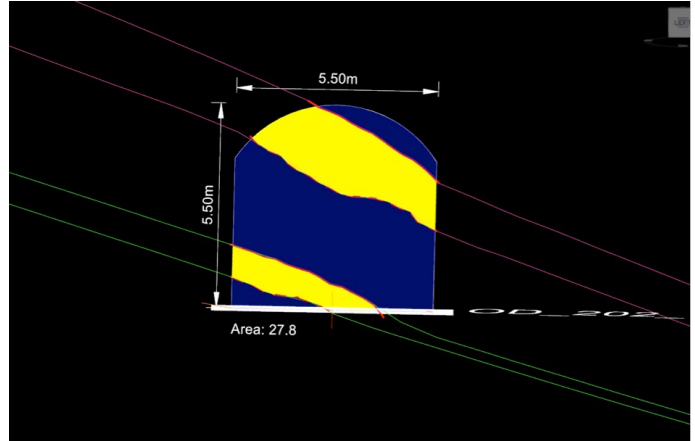
Check the boxes for the outputs that are to be exported and ensure the format is set to Leapfrog Model Files. Click **Export**.



To import the meshes to Deswik.CAD, go to **File | Import | Leapfrog Model**.



The meshes can be reviewed against all your underground mapping, as well as development and stopes.

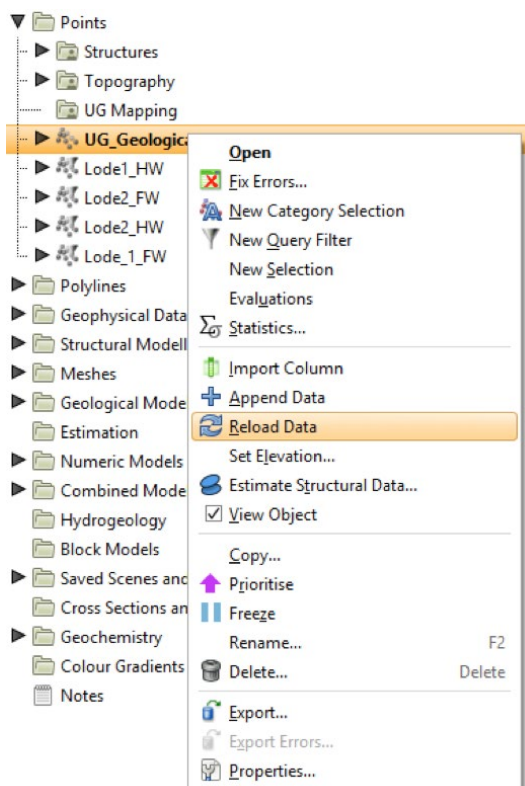


Updating your Underground Model

This Leapfrog Geo workflow allows for dynamic updating of geological models as your mapping is updated. After you set up the selections and filters, it is an easy process to reload the raw mapping data as new information becomes available, ensuring that models are always up to date.

As new mapping is completed, the updated mapping information can be exported from Deswik. Inside Leapfrog, your workflow as already been set up. All you need to do is reload the points information.

Right-click your Underground Mapping points and then click **Reload Data**.



This dual workflow allows for a robust and consistent underground mine mapping program with up to date implicit geological models. Pair Seequent's Leapfrog Geo and Deswik. GeoTools into a single industry leading workflow for smarter mining. For more information, go to:

<http://www.leapfrog3d.com/downloads>

<https://www.deswik.com/deswik-geotools/>

Leapfrog Geo's dynamic workflows enhance the geological modeling process, allowing geologists to monitor underground vein geometry and position in rapid time to aid with reducing dilution and assist mine development and stope design. Deswik. Mapping improves the consistency of geological mapping by enabling geologists to use standardized methods, styles and formats when recording their observations ensuring that all data is captured to an agreed standard. The above work can be used for Face as well as Backs Mapping.

