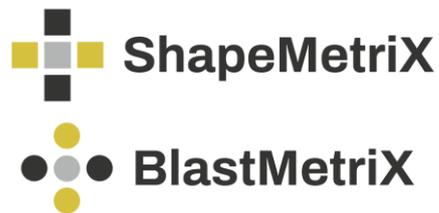


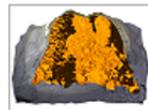
User Manual

3GSM

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SMX VolumeCalculator



**User Manual
for Version 4.11**

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Author: 3GSM

Subject to change without notice

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1 Introduction

The *SMX VolumeCalculator* is an easy to handle software component of the *SMX ShapeMetriX* or *BMX BlastMetriX* software package. The software permits volume estimations from scaled 3D models. The *SMX Volume Calculator* requires input data from the *SMX MultiPhoto*, which is a software component for generating 3D models from digital imaging using a UAV system. Three modes are available in the *SMX VolumeCalculator*:

1. *Heap Mode (Two Models)* - heap volumes are derived from two superimposed 3D models (pre versus post situation) from repeated digital imaging
2. *Heap Mode (One Model)* – heap volumes are derived from a 3D model and user adjustable *Boundary Planes*
3. *Underground Mode* – volumes are derived from two superimposed 3D model from repeated digital imaging by the generation of a watertight 3D mesh. The mode is specially designed for underground applications.

This user manual addresses all topics related to the *SMX VolumeCalculator* i.e. installation, user interfaces, features and operations. Let us know if we can support you, and give us your valuable feedback. Only this way it remains possible to keep the system both, flexible enough for broad usage and sufficiently specific for your applications.

We wish you success with the *SMX VolumeCalculator*.

The Team of 3GSM

Graz, October 2024

2 General

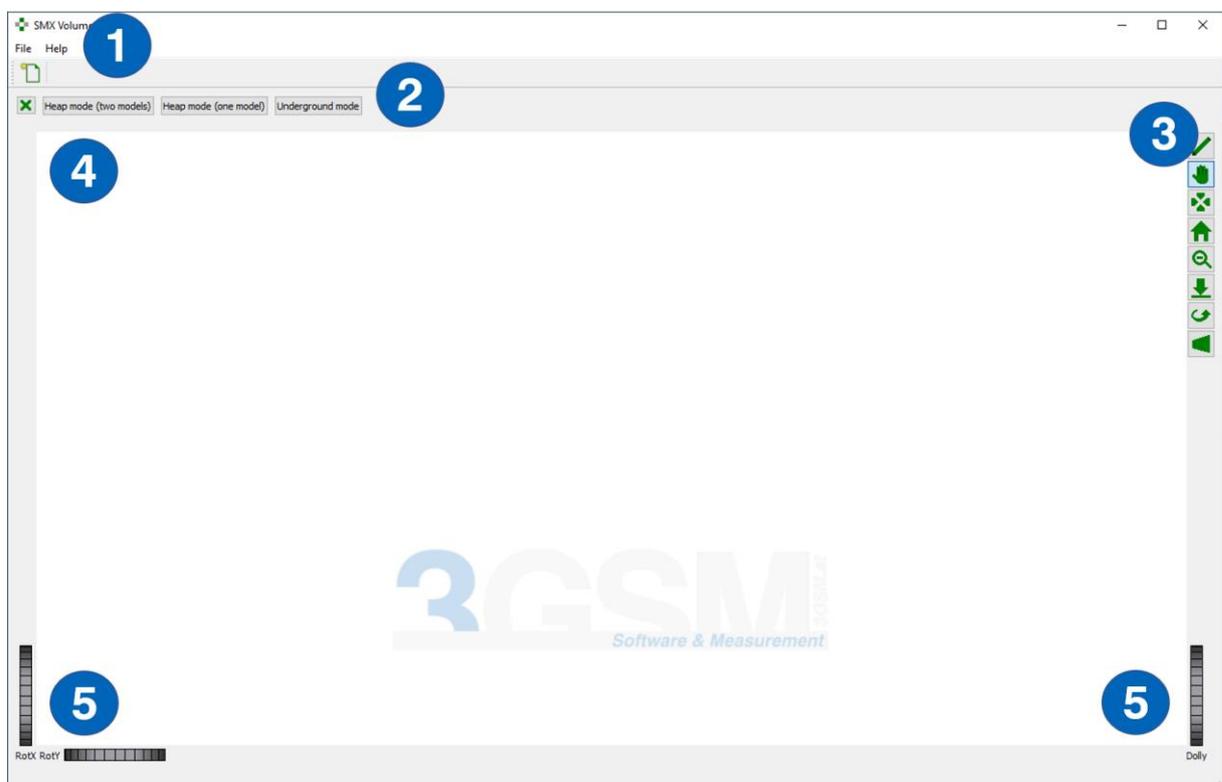
The *SMX VolumeCalculator* is part of the *ShapeMetriX/BlastMetriX* package and not available as a stand-alone program. The installation takes place during the installation of *ShapeMetriX/BlastMetriX* and is described in the corresponding user manual.

Note:

The *SMX VolumeCalculator* software component is also used under this name in the *ShapeMetriX* and *BlastMetriX* packages, i.e. there is no dedicated *BMX VolumeCalculator*. The same may apply to other software components.

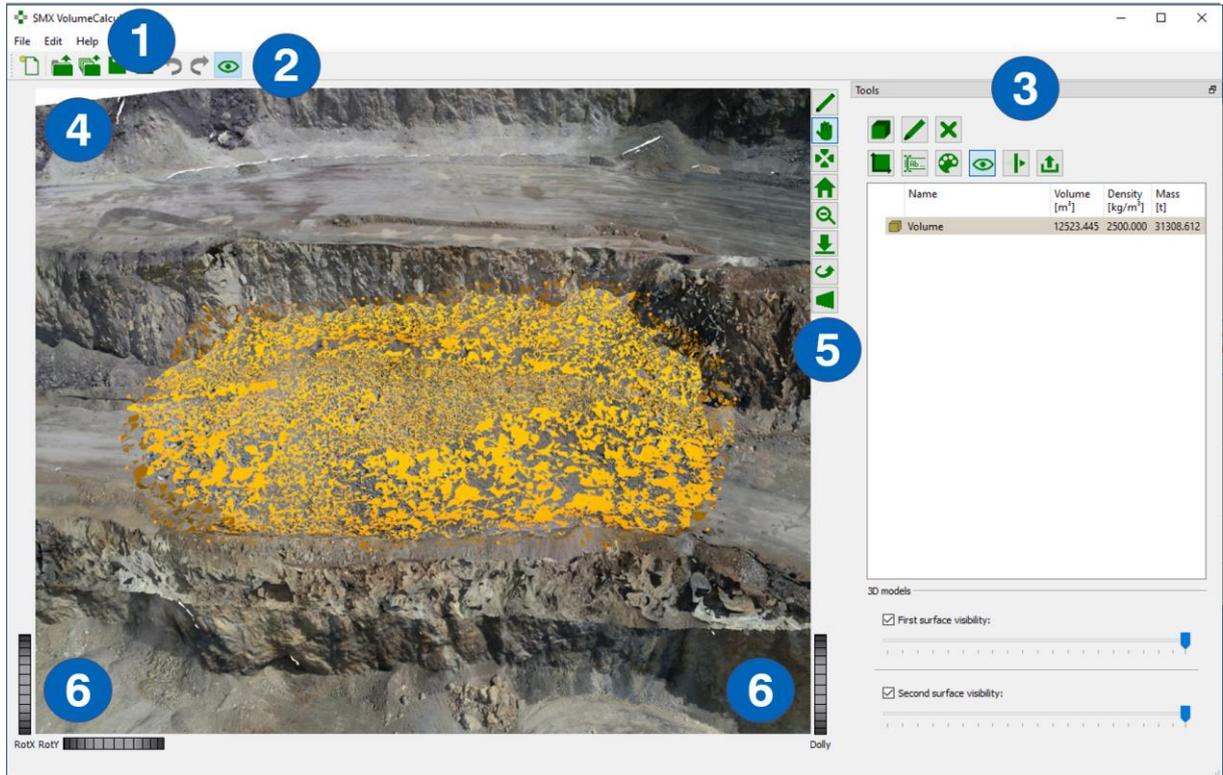
3 User interface

The user interface of the *SMX VolumeCalculator* (Figure 1 and Figure 2) comprises the menu bar, toolbars, the navigation bar, the 3D viewer, and thumb wheels.



- 1 Menu bar
- 2 Toolbar
- 3 Navigation bar
- 4 3D viewer
- 5 Thumb wheels

Figure 1: User interface of the *SMX VolumeCalculator* - Selection of Mode



- 1 Menu bar
- 2 Toolbar
- 3 *Tools* pane
- 4 3D viewer
- 5 Navigation bar
- 6 Thumb wheels

Figure 2: User interface of the SMX VolumeCalculator Heap Mode (Two Models)

4 Features

This section describes the available functions of the *SMX VolumeCalculator*.

4.1 Context menu of the 3D viewer

The context menu of the 3D viewer allows the change in the display of the 3D model. A click on the right mouse button in the viewer opens a pop up window and several options can be chosen:

<i>Draw as is</i>	The 3D topography is completely overlaid by the digital photograph (3D model)
<i>Wireframe</i>	A triangulated red coloured point cloud is forming the topography
<i>Wireframe Overlay</i>	The 3D model and a red coloured overlay of the wireframe is forming the topography
<i>Points</i>	The point cloud of the scene according to the topography is shown
<i>All Points</i>	All available points of the 3D model according to the photograph are shown
<i>Fullscreen</i>	Switches between the fullscreen display and the windowed display
<i>Show Texture</i>	Displays the 3D model with texture in the viewer
<i>Show Axes</i>	Turns the co-ordinate axes on and off
<i>Show Bounding Box</i>	Turns the bounding box surrounding of the 3D model on and off

4.2 Menu bar

File Edit Help

The menu bar comprises three main menus. The menu commands are accessible using the mouse cursor. The following paragraphs describe the structure and commands of the two main menus (*File*, *Edit* and *Help*).

Menu File

<i>New Calculation</i>	Starts a new project
<i>Generate Screenshot</i>	Generates a user-defined screenshot
<i>Generate Report</i>	Writes a report directly to a “.pdf” file
<i>Exit</i>	Closes the program

Menu Edit (for Heap Modes)

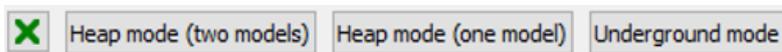
<i>Undo</i>	Revokes the previously executed commands step by step
<i>Redo</i>	Redoes commands revoked by the “Undo” function step by step
<i>Export Volumes as CSV</i>	Exports the volume data as “.csv” file

Menu Edit (for *Underground Mode*)

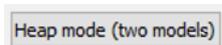
<i>Undo</i>	Revokes the previously executed commands step by step
<i>Redo</i>	Redoes commands revoked by the “ <i>Undo</i> ” function step by step
<i>Recalculate</i>	Start volume calculations
<i>Draw Polygon</i>	Divides a point cloud into two segments using a polygon
<i>Toggle Target</i>	
<i>Invert Selection</i>	Inverts the selection of points to delete
<i>Import</i>	
<i>Volume Model from OBJ</i>	Imports volume data from “.obj”
<i>Export</i>	
<i>Volume Model as OBJ</i>	Exports volume data as “.obj”
<i>Volume Model as DXF</i>	Exports volume data as “.dxf”

Menu Help

<i>User Manual</i>	Opens the manual of the software component
<i>Units</i>	Displays the units used by the software
<i>About Volume Calculator</i>	Displays versions and release information of the software component

4.3 Toolbars**Toolbar 1***Close*

Closes the toolbar

Heap Mode (Two Models)Enters the *Heap Mode (Two Models)**Heap Mode (One Model)*Enters the *Heap Mode (One Model)**Underground Mode*

Underground mode

Enters the *Underground Mode*

Note:

To enter the main menu a *Mode*, i.e. “*Heap Mode (Two Models)*”, “*Heap Mode (One Model)*” or “*Underground Mode*”, has to be selected.

Toolbar 2



New Calculation



Starts a new project

Load 3D Models



Loads 3D models (“.jm3” files)

Load Project



Loads a project file (“.vol” file)

Save Project



Saves the volumes (“.vol” file)

Save Project as



Renames and saves the volumes (“.vol” file)

Undo



Revokes the previously executed commands step by step

Redo



Redoes commands revoked by the “*Undo*” function step by step

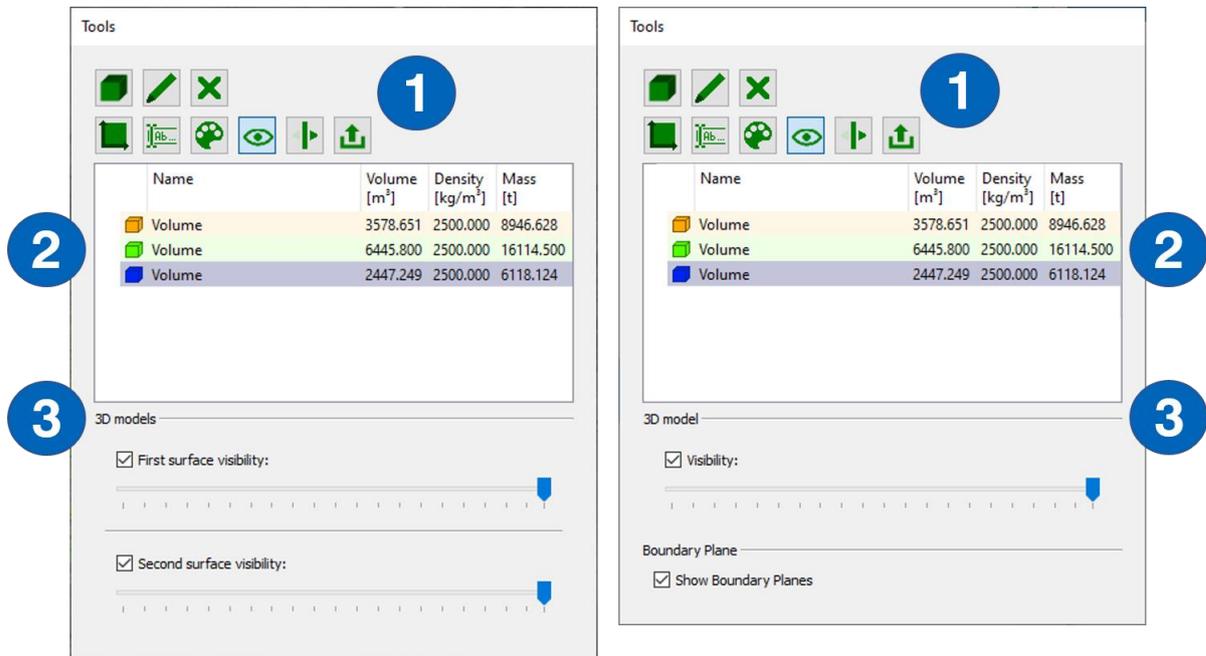
Toggle Volume Visibility



Hides/shows volumes

4.4 Tools pane (Heap Modes)

The *Tools* pane shown in Figure 3 provide features for the *Heap Mode* including the results displayed in the *Volume* list. In addition the visibility of the 3D model(s) and *Boundary Planes*(s) can be adjusted.



- 1 Toolbar
- 2 Volumes list
- 3 Visibility of 3D model(s) / Boundary Planes

Figure 3: Left: Tools pane Heap Mode (Two Models). Right Tools pane Heap Mode (One Model).

New Heap Volume



Activates the features of the toolbar for defining a heap volume by a polygon

Edit Heap Volume



Enables editing of the heap polygon

Delete Heap Volume



Deletes generated heap volumes

Use Reference Plane for Empty Areas – Heap Mode (Two Models)



Replaces empty areas of a 3D model by the *Reference Plane* (see *Surface Trimmer* manual)

Edit Boundary Plane – Heap Mode (One Model)



Enables editing of the *Boundary Plane(s)*

Rename



Renames the active heap volume

Set Colour



Changes the colour of the active heap volume

Toggle Visibility



Hides/Shows the active heap volume

Invert



vice versa

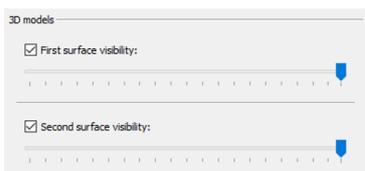
Inverts the determined volume value i.e. negative to positive balance and

Export



Exports heap volume data as “.obj” or “.dxf” files

3D Models – Heap Mode (Two Models)



Changes the visibility of the first and second loaded 3D model on the screen

3D Models Heap Mode (One Models)



Changes the visibility of the 3D model on the screen

Enables the visibility of the *Boundary Planes*

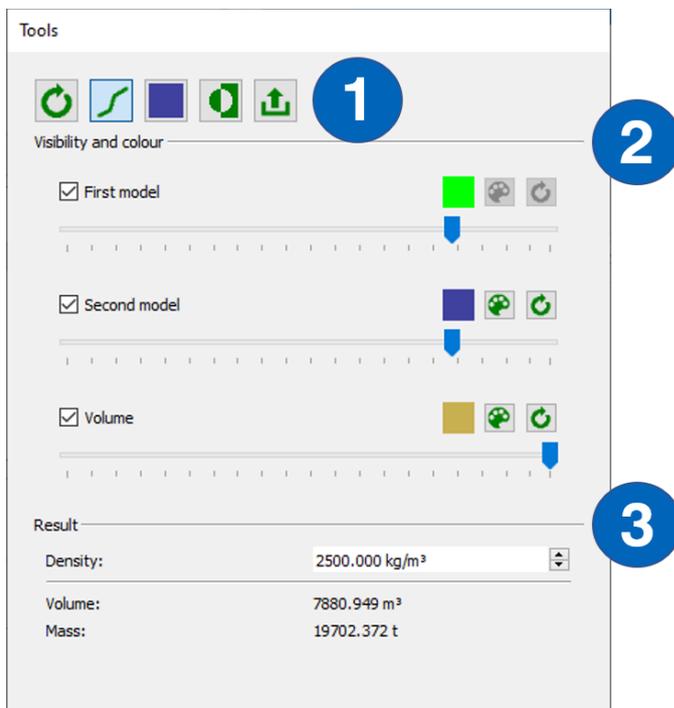
Context menu of volumes

The features of the *Tools* pane are available in the context menu of individual volumes by a click on the right mouse button in the tree widget. In addition following features are available:

- *Edit Density* Enables to edit the density of the active volume
- *Assign Density to All* Assigns the density of the active volume to all volumes

4.5 Tools pane (Underground Mode)

The *Tools* pane shown in Figure 3 provide features for the *Underground Mode* including the result. In addition the visibility of the 3D models and the volume can be adjusted.



- 1 Toolbar
- 2 Visibility and colour
- 3 Result

Figure 4: Tools pane Underground Mode

Recalculate



Start volume calculations

Draw Polygon

Divides a point cloud (3D model) into two segments using a polygon

Toggle Target

Toggles between the target models to be trimmed, i.e. the first, the second, or both models at the same time

Invert Selection

Inverts the selection of points to delete

Export Volume

Exports volume data as “.obj” or “.dxf” file

4.6 Navigation bar**Hint:**

The *SMX VolumeCalculator* toggles between the *Edit* and *Navigate* mode by pressing the “Esc” key.

Edit

Performs actions within the 3D model such as marking annotations, etc. (active = blue)

Navigate

Controls the motion and inspection of a 3D model (active = blue)

Seek to a Selected Point

Zooms towards the selected location on the 3D model

Move to Home Position

Sets the viewer to its initial position

Zoom out / Zoom in



Zooms out from the current view. Zooms to the previous view again.

Top Down View



Orientates the 3D model from the camera view (top down).

Auto Rotate (fixed or view)



Rotates the 3D model from a fixed point (top down) or from the current point of view

Toggle Perspective/Parallel Projection



Toggles between perspective and parallel projection

Thumb wheels

The thumb wheels are used for rotation and zooming

4.7 Navigation mode

The devices used in the *Navigate* mode are the mouse and/or the keyboard.

Mouse navigation

- Rotation: The left mouse button rotates the 3D model. Just keep the left button pressed and move the mouse around to see the 3D model rotating.
- Context menu: The right mouse button opens a context menu where the representation of the 3D model can be influenced.
- Panning: The middle mouse button is used to pan the 3D model. The same can be done by pressing “Ctrl” or “Shift” and using the left mouse button.
- Zooming: Pressing the left and middle mouse button at the same time is used to zoom. The same can be done by pressing “Ctrl” and “Shift” and using the left mouse button. When turning the wheel of a wheel mouse the 3D model is also zoomed.

Hint:

It is preferred to have a mouse with 3 buttons, or a wheel mouse. Usually the wheel acts as the third mouse button.

Keyboard navigation

- Straight motion is performed by pressing the corresponding arrow key *“Left”*, *“Right”*, *“Up”* or *“Down”*.
- Zooming is performed by pressing *“Shift”* simultaneously with the arrow key *“Up”* for zooming in and the arrow key *“Down”* for zooming out.
- Rotation of the 3D model in a desired direction is performed by pressing *“Ctrl”* simultaneously with the corresponding arrow key *“Left”*, *“Right”*, *“Up”* or *“Down”*.

5 Heap Mode - Two Models

The *Heap Mode (Two Models)* supports heap volume calculations from two superimposed 3D models derived from repeated digital imaging of a region (pre and post situation). Primary settings, e.g. pre-existing heap on the floor level or roughed terrains, are considered in volume calculations.

Note:

Models have to be in the same co-ordinate system (referencing in the *SMX MultiPhoto*; see corresponding user manual).

5.1 Standard operation procedure

1. Select “*Heap Mode (Two Models)*” in toolbar 1 after launching the *SMX VolumeCalculator*.
2. Load the 3D models one after the other by clicking the “*Load 3D Models*”  icon in toolbar 2. Check the images for plausibility with the sliders “*First Surface Visibility*” and “*Second Surface Visibility*” (see Figure 5).
3. Define a heap volume by following procedure (see Figure 6):
 - a. Click in the “*New Heap Volume*”  in the *Tools* pane.
 - b. Click the “*Edit Heap Volume*”  icon in the *Tools* pane and define the boundary of the heap on the 3D model by clicking the left mouse button. A polygonal line grows instantaneously. At least three points are required. Undo the last action by pressing the right mouse button (multiple uses possible).
 - c. Confirm the boundary of the heap by a click on the middle mouse button or by the “*Return*” button on the keyboard. The volume is now set and appears as coloured item in the viewer. The calculated volume is available in *Volume* list in the *Tools* pane.
 - d. Enter the rock density for weight calculations in the tree widget for volumes.
4. Save the volume as “.vol” file by clicking “*Save*”  icon or “*Save Project As*”  icon in the toolbar.
5. Close the program in the menu bar with “*File | Exit*”.

Attention:

The calculation of the mesh of the 3D model in the *SMX MultiPhoto* is may not feasible in some areas due to e.g. insufficient overlapping of images. This “empty area” can be replaced by a *Reference Plane* by click on the “*Use Reference Plane for empty areas*”  icon in the *Tools* pane. Note, the position of the *Reference Plane* can only be adjusted in the *SMX SurfaceTrimmer* (see corresponding manual).

Note:

The software performs volume calculations by subtracting the second loaded mesh (3D model) from the first loaded one. Therefore, calculated volumes are possibly given in negative values. Invert signs by clicking the “*Invert*”  icon in the *Tools* pane.

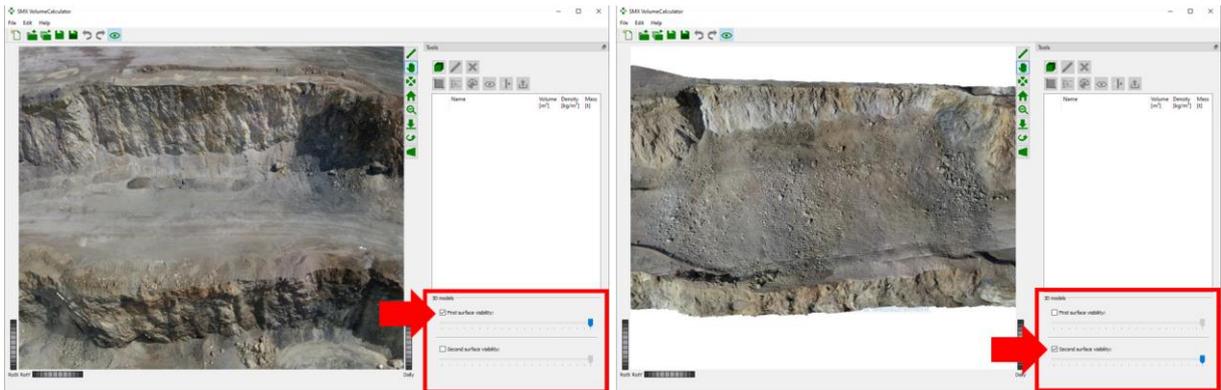


Figure 5: Loaded 3D models of a quarry: left before blast; right after blast



Figure 6: Top left: Activation of heap volume editing. Top right: Editing of heap volume by drawing a polygon. Bottom left: Confirmation of the polygon. The defined volume body is coloured and the results is shown in the Tools pane. Bottom right: Weight calculations require the input of the rock density in the tree widget.

Hint:

A number of heap volumes can be determined on one 3D model setup by repeating step 3 of the standard operation procedure (see Figure 7).

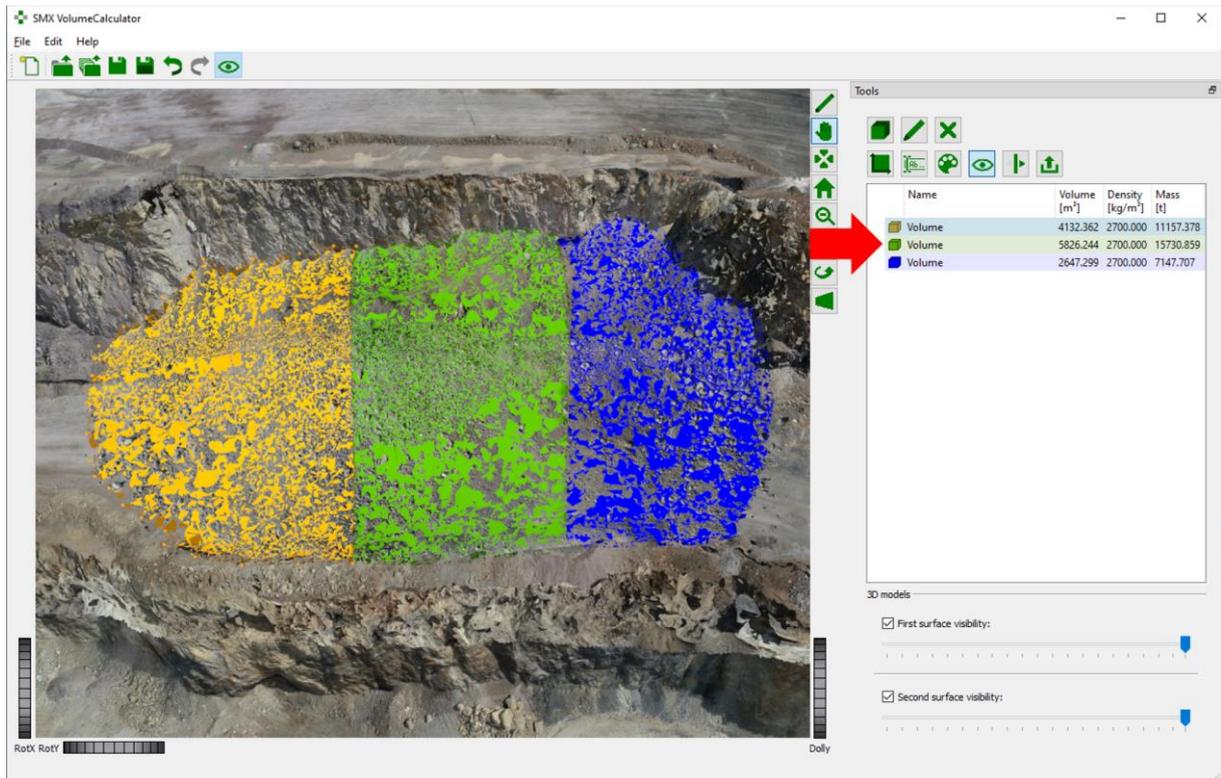


Figure 7: Determination of multiple heap volumes

5.2 Editing of heap volumes

The boundary of the heap volume can be adjusted by following procedure (see Figure 8):

1. Select the volume to edit in the tree widget (*Volume* list).
2. Click “*Edit Heap Volume*”  in the toolbar. The *Edit* mode is active (navigation bar) and the clicked points of the boundary polygon appear.
3. Edit the heap volume by the use of following keyboard and mouse functions:
 - Press “*Shift*” and use the left mouse button to move single points of the boundary polygon.
 - Press “*Ctrl*” and use the left mouse button to insert a point
 - Use the right mouse button to delete the last point of the polygon
 - Press “*Shift*”, “*Ctrl*” and the right mouse button to delete the last point inserted
4. Relieve the mouse button and confirm the polygon by a click on the middle mouse button or by the “*Return*” button on the keyboard.

Hint:

Volume calculation are possibly unfeasible through the change in the view position during editing, i.e. the polygon cannot be accurately closed by the software. Edit the boundary of the heap volume to activate a *View Dependent Redraw* of the polygon.

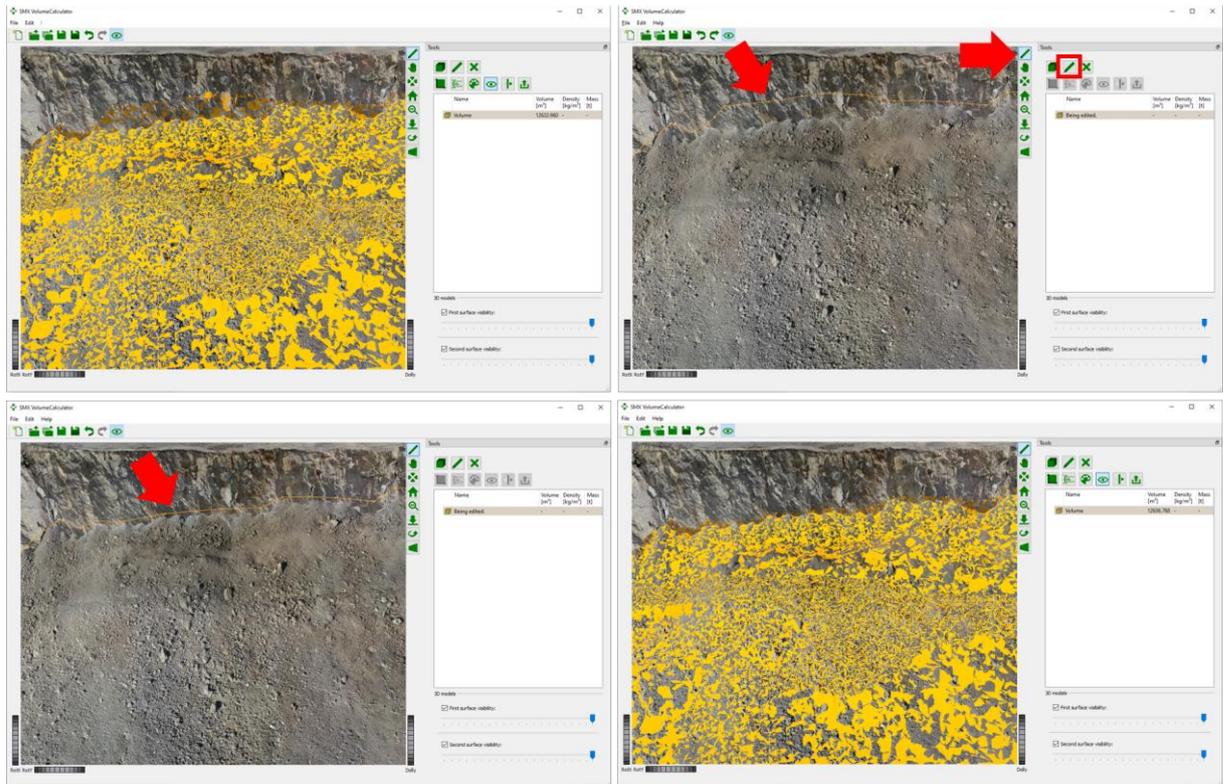


Figure 8: Edit of the heap boundary

Volumes are:

- deleted by clicking “Delete Heap Volume”  icon in the *Tools* pane
- renamed by clicking “Rename”  icon in the *Tools* pane
- changed in colour by clicking “Set Colour”  icon in the *Tools* pane
- hidden in the viewer by clicking “Toggle Visibility”  icon in the *Tools* pane. All heap volumes are hidden with a click on the icon “Toggle Volume Visibility”  icon in toolbar.

6 Heap Mode - One Model

The *Heap Mode (One Model)* features volume calculations between a 3D model and a *Boundary Plane*. The *Boundary Plane* is generated automatically by the software from the volume polygon drawn on the 3D model by the user. However, the position of the *Boundary Plane* can be modified interactively.

Note:

Boundary Planes are calculated for each individual volume.

6.1 Standard operation procedure

1. Select “*Heap Mode (One Mode)*” in the toolbar 1 after launching the *SMX VolumeCalculator*.
2. Load a 3D model by a click on the “*Load 3D Model*”  icon in the toolbar.
3. Define a heap volume by following procedure (see Figure 9):
 - a. Click in the “*New Heap Volume*”  icon in the *Tools* pane.
 - b. Click the “*Edit Heap Volume*”  in the *Tools* pane and set the border line (at least 3 points) on the 3D model by clicking the left mouse button. A polygonal line grows instantaneously. Undo the last action by pressing the right mouse button (multiple uses possible).
 - a. Confirm the boundary of the heap by a click on the middle mouse button or by the “*Return*” button on the keyboard. The volume is now set and appears as coloured item with its automatically generated *Boundary Plane* in the viewer. The calculated volume is available in *Volume* list in the *Tools* pane.
 - c. Edit the position of the *Boundary Plane* if necessary (Chapter 6.3).
 - d. Optional! Invert the determined volume value i.e. negative to positive balance and vice versa by clicking the “*Invert*”  icon in the *Tools* pane.
4. Enter the rock density for weight calculations in the tree widget for volumes.
5. Save volumes as “.vol” file by clicking “*Save*”  or “*Save Project As*”  in the toolbar.
6. Close the program in the menu bar with “*File | Exit*” in the menu bar.

Note:

A number of heap volumes can be determined on one 3D model setup by repeating step 3 of the standard operation procedure (see Figure 7 in Chapter 5.1).

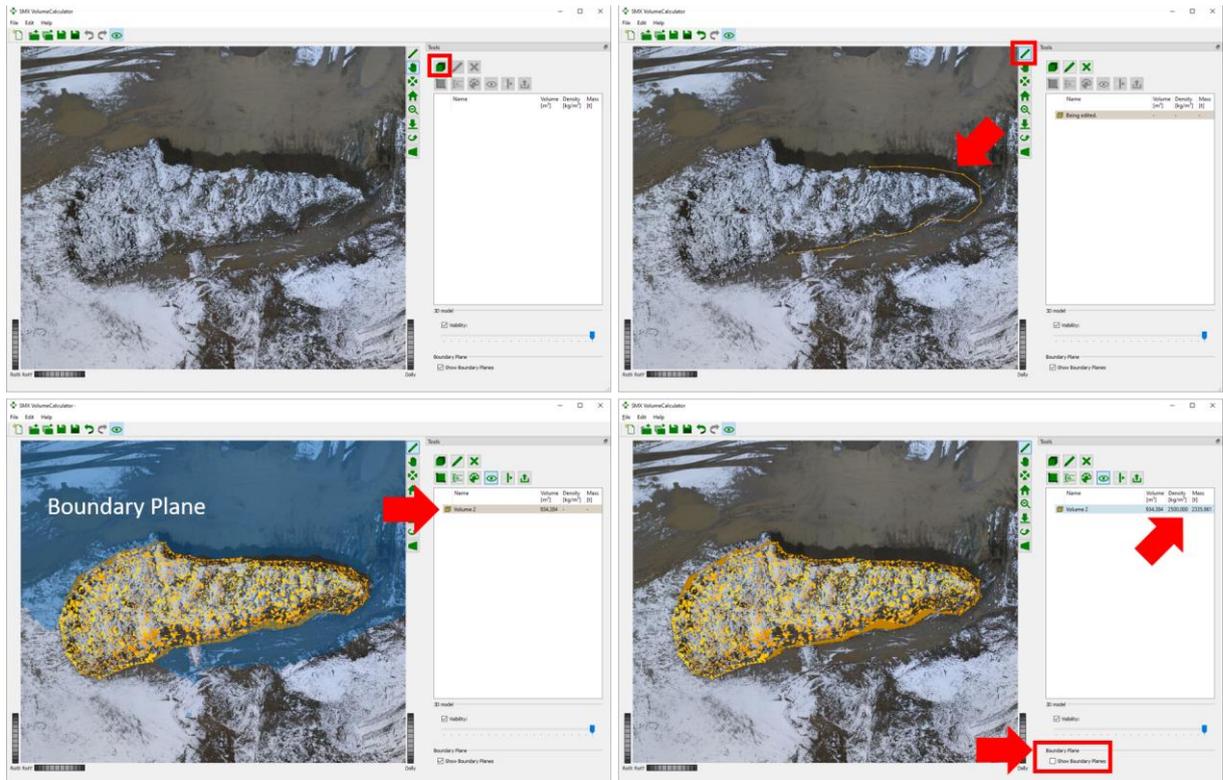


Figure 9: Top left: Activation of heap volume editing. Top right: Editing of heap volume by drawing a polygon. Bottom left: Confirmation of the polygon. The defined volume body is coloured and the calculated volume appears in the Tools pane. In addition, the Boundary Plane is shown in the viewer. Bottom right: Weight calculations require the input of the rock density in the tree widget. Note, the Boundary Plane is hidden by enabling the corresponding checkbox.

6.2 Editing of heap volumes

The boundary of the heap volumes can be adjusted by following procedure (see Figure 8 in Chapter 5.2):

1. Select the volume to edit in the tree widget.
2. Click “Edit Heap Volume”  in the toolbar. The *Edit* mode is active (navigation bar) and the clicked points of the boundary polygon appear.
3. Edit the heap volume by the use of following keyboard and mouse functions:
 - a. Press “Shift” and use the left mouse button to move single points of the boundary polygon.
 - b. Press “Ctrl” and use the left mouse button to insert a point
 - c. Use the right mouse button to delete the last point of the polygon
 - d. Press “Shift”, “Ctrl” and the right mouse button to delete the last point inserted
4. Relieve the mouse button and confirm the polygon by a click on the middle mouse button or by the “Return” button on the keyboard.

Hint:

Volume calculation are possibly unfeasible through the change in the view position during editing, i.e. the polygon cannot be accurately closed by the software. Edit the boundary of the heap volume to activate a *View Dependent Redraw* of the polygon.

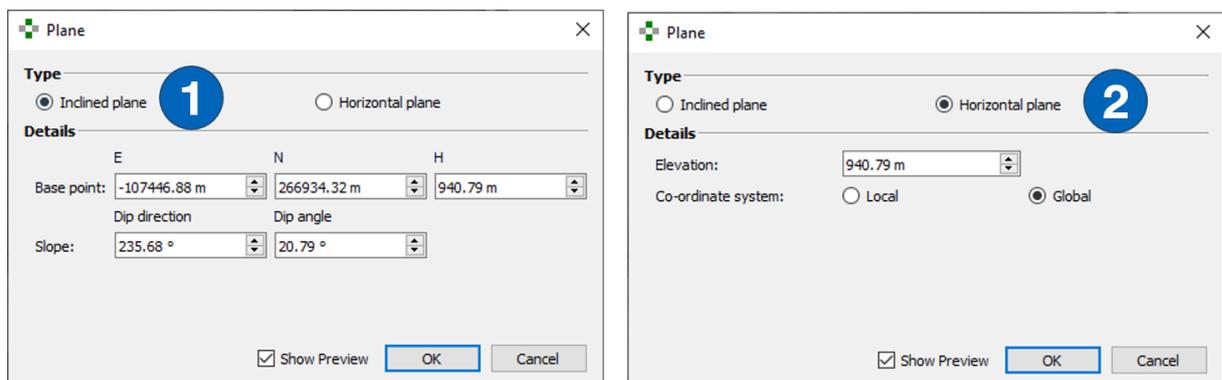
Volumes are:

- deleted by clicking “Delete Heap Volume”  icon in the *Tools* pane
- renamed by clicking “Rename”  icon in the *Tools* pane
- changed in colour by clicking “Set Colour”  icon in the *Tools* pane
- hidden in the viewer by clicking “Toggle Visibility”  icon in the *Tools* pane .All heap volumes are hidden with a click on the icon “Toggle Volume Visibility”  icon in toolbar.

6.3 Editing of the Boundary Plane

The position of the *Boundary Plane* can be adjusted by the user by click on the “Edit Boundary Plane”  icon in the *Tool* pane. Following possibilities are provided:

1. “Edit Plane” – adjusts the *Boundary Plane* on the basis of the input parameters (see Figure 10):
 - a. Inclined plane
 - Co-ordinate system (Easting, Northing, Height)
 - Slope (dip direction and dip angle)
 - b. Horizontal plane
 - Elevation
 - Co-ordinate system (Local or Global)
2. “Set from Polygon – sets the *Boundary Plane* from the heap polygon
3. “Set from other Volume” – defines the *Boundary Plane* from another volume



- 1 Define inclined plane
- 2 Define horizontal plane

Figure 10: Plane dialog for adjusting the Boundary Plane

7 Underground Mode

The *Underground Mode* supports volume calculations from two superimposed 3D models derived from repeated digital imaging of a region (pre and post situation). 3D models need to be trimmed, that only the two surfaces enclosing the volume to be calculated remains. The volume is achieved by the generation of a watertight volume mesh.

Note:

Models have to be in the same co-ordinate system (referencing in the *SMX MultiPhoto*; see corresponding user manual).

Standard operation procedure

1. Select “*Underground Mode*” in toolbar 1 after launching the *SMX VolumeCalculator*.
2. Load the 3D models one after the other by clicking the “*Load 3D Models*”  icon in toolbar 2. Check the images for plausibility with the sliders “*First Model*” and “*Second Model*” (see Figure 11).

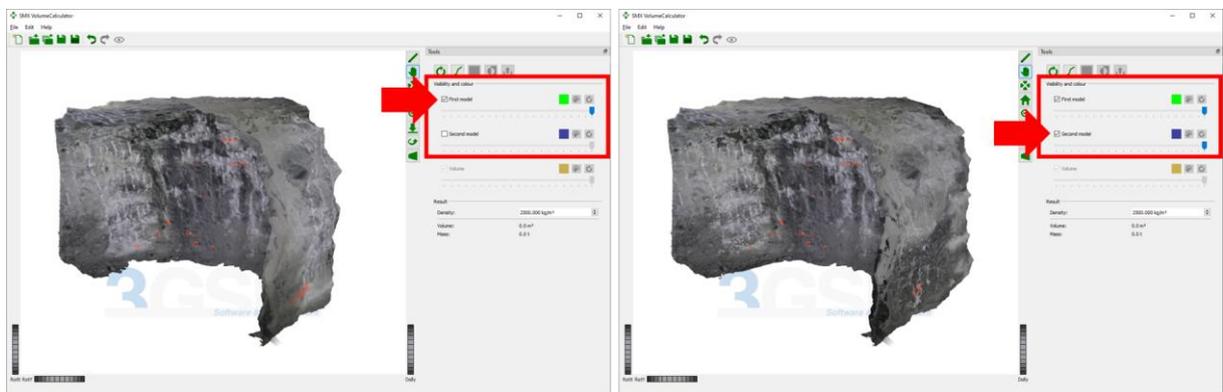


Figure 11: Loaded 3D models of a tunnel excavation: left first model; right second model

3. Trim the 3D models that only the volume body to be calculated remains by following procedure:
 - a. Start the trimming procedure by clicking “*Edit | Draw Polygon*” in the menu bar or use the according icon  in the toolbar. The 3D models are displayed with a colour overlay in the viewer (Figure 12).

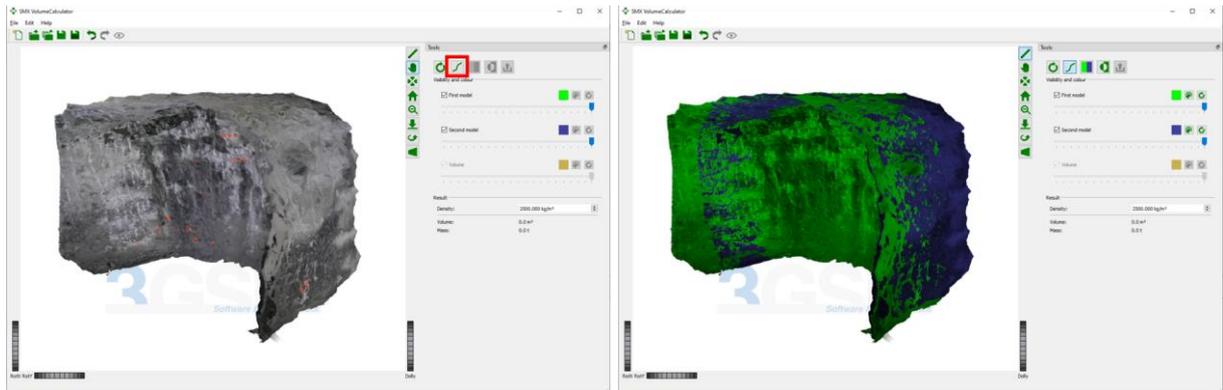


Figure 12: Left: 3D models (first and second) in the 3D viewer. The 3D models are displayed with a colour overlay after activating the trimming procedure. The green overlay refers to the first model while the blue overlay refers to the second model.

Note:

The colour overlay is customized in the *Colour* dialog which opens by clicking the “Pick Colour”  icon in the *Tools* pane.

- b. Toggle between the target 3D model, i.e. the 3D model to trim by clicking “Edit | Toggle Target” in the menu bar or use the according icon  in the toolbar. The model(s) to be trimmed appear(s) with the defined colour overlay.
- c. Enclose the region to delete by dragging the cursor across the 3D model while keeping the left mouse button pressed. After releasing the mouse button, the selected region is highlighted in red (Figure 13).
- d. Delete the region by pressing the middle mouse button.

Hint:

Press “Shift” while keeping the left mouse button pressed to draw a straight line.

Hint:

The selection of points is inverted by clicking the “Invert Selection”  icon in the *Tools* pane. Previously unselected areas are now highlighted and will be deleted by pressing the middle mouse button.

- e. Go on trimming until the surfaces of the 3D models are reduced to the volume to be calculated.
- f. Press the “Recalculate”  icon in the toolbar of the *Tools* pane to start volume calculation. A watertight volume body is generated and the result is immediately displayed on the 3D viewer and in the *Tools* pane.

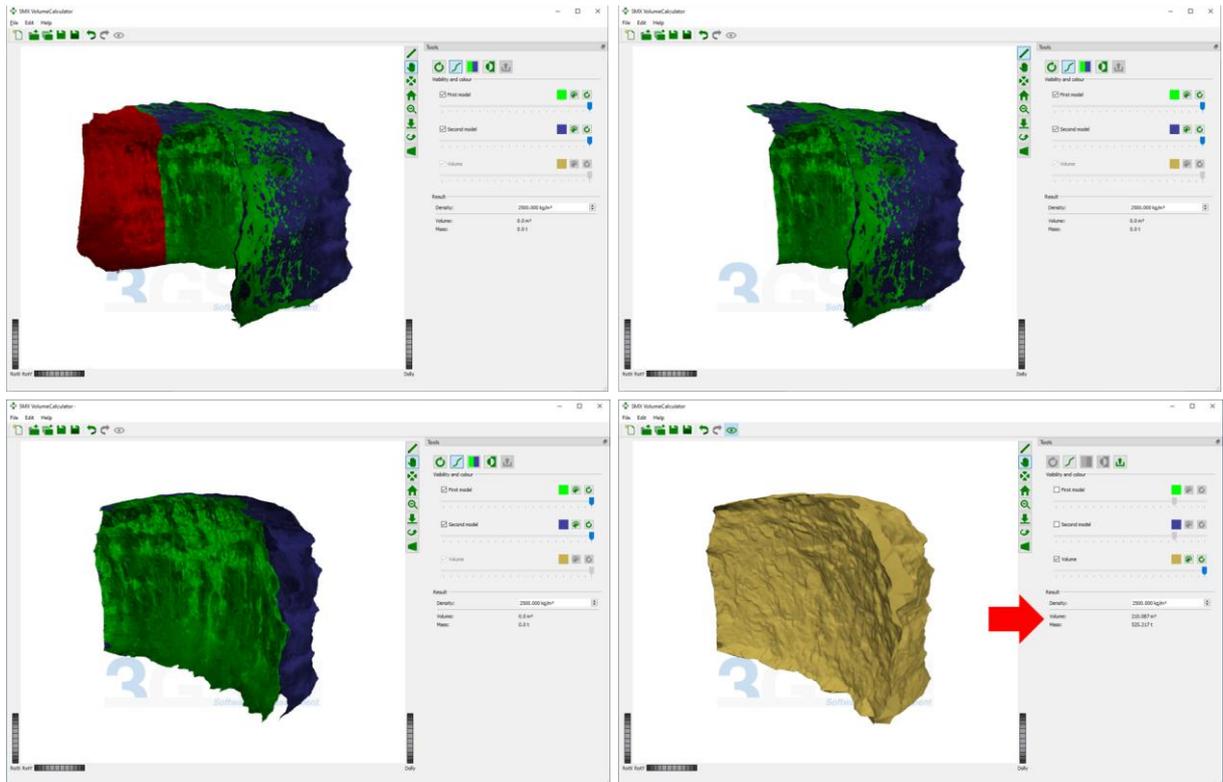


Figure 13: Top left: Region to delete enclosed by a polygon- Top right: Trimming of the 3D model. Bottom left: Trimmed 3D models. Bottom Right:

4. Save the volume as “.vol” file by clicking “Save”  icon or “Save Project As”  icon in the toolbar.
5. Close the program in the menu bar with “File | Exit”.

8 Report and export

8.1 Report

The *SMX VolumeCalculator* automatically generates a report to a “.pdf” file by clicking “File | Generate Report” (Figure 14). The report includes the key data of the current project (date of report generation, project name, data and description), an ortho-photo with the volumes and the corresponding parameters (i.e. volume, rock density and mass).

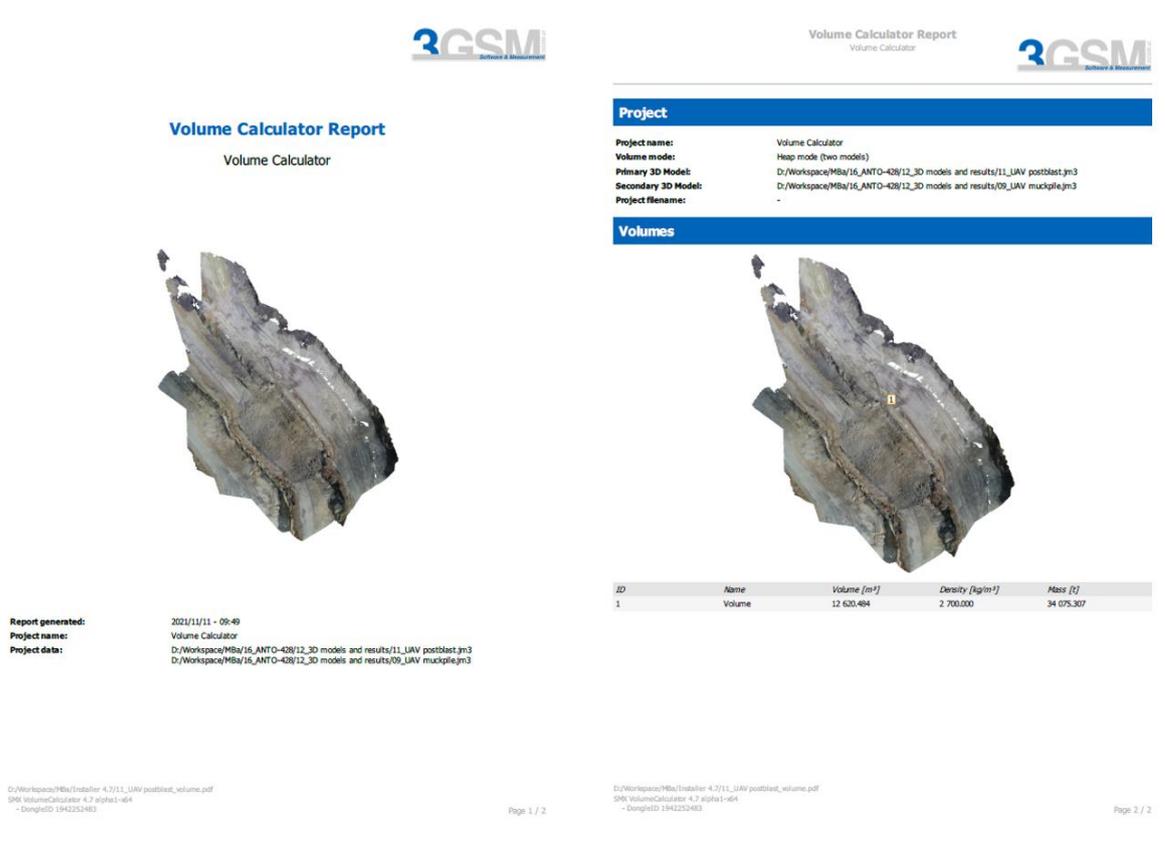


Figure 14: SMX VolumeCalculator Report

8.2 Export and Import

Heap Modes

The volume data is exported as “.obj” or “.dxf” by clicking the “Export”  icon in the *Tools* pane or in the context menu of the volume. The volume data is exported as “.csv” by clicking “File | Export Volumes as CSV”.

Example “Export Volumes as CSV”:

```
"ID";"Name";"Volume [m³]";"Density [kg/m³]";"Mass [t]"  
1;"Volume";2236,3585;2700;6038,16  
2;"Volume";7064,039;2700;19072,90  
3;"Volume";3223,1075;2700;8702,38
```

Underground Mode

The volume data is exported as “.obj” or “.dxf” by clicking the “Export”  icon in the *Tools* pane or by using “Edit | Export | Volume Model as OBJ” and “Edit | Export | Volume Model as DXF” in the menu bar. Volume models are imported from “.obj” by using “Edit | Import | Volume Model from OBJ” in the menu bar.

8.3 Screenshot

Menu bar: “File | Generate Screenshot”: Writes a “.jpeg” file of the scene in the 3D viewer using off-screen rendering, i.e. the screen shot model is dependent from the native of the monitor display. The export of the screenshot can be modified in the screenshot dialog (Figure 15), which opens subsequently after calling the command. Camera type, camera position and direction, and several settings options can be selected for the screenshot export.

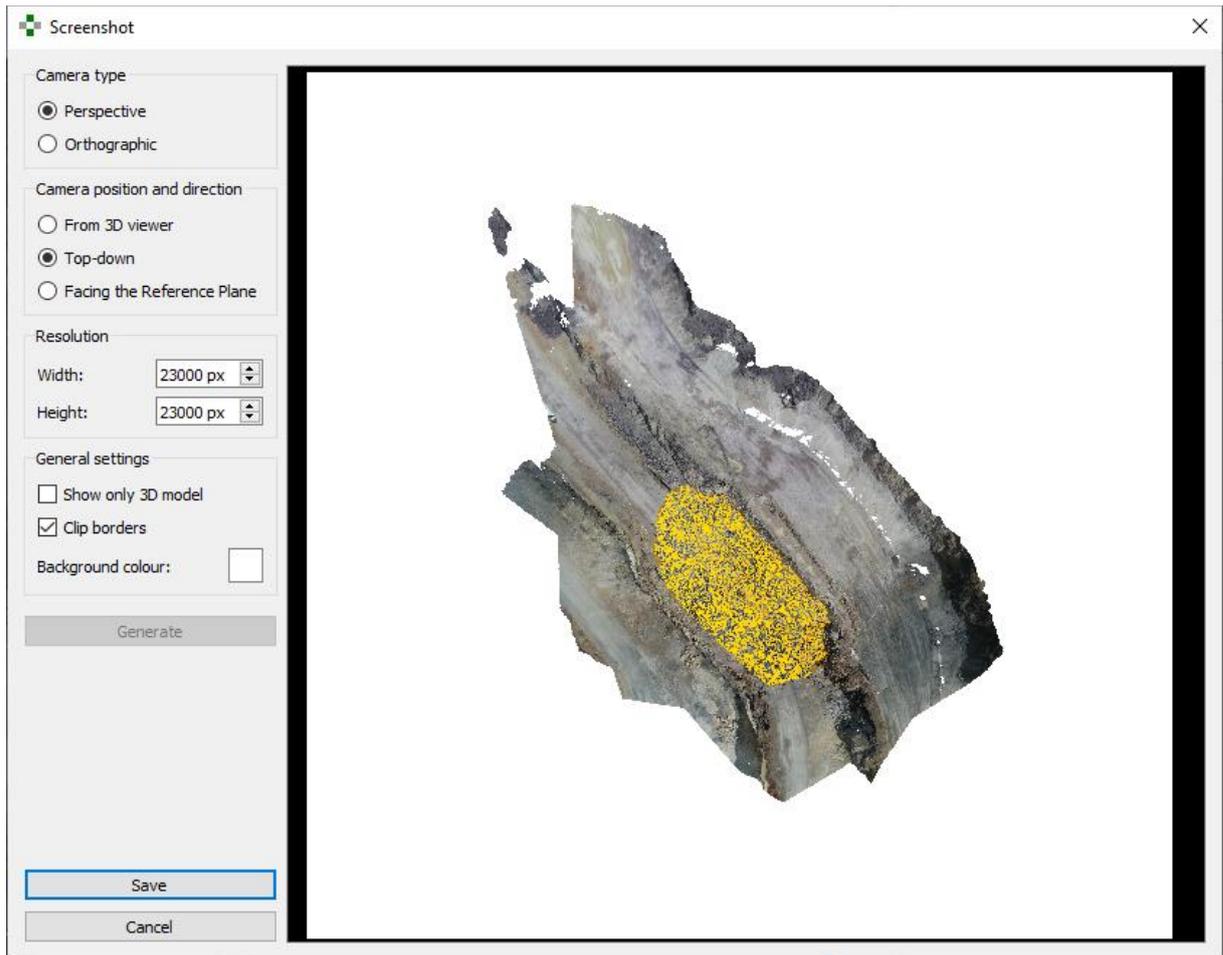


Figure 15: Export dialog for screenshot