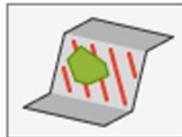# 3GSM

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ShapeMetriX

Analyst

User Manual

for Version 5.0

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Project ID: 6100 Author: 3GSM	*Subject to change without notice*

CONTENTS

Introduction

The *Analyst* is a software component serving for the visualisation and assessment of 3D models. The software provides a mechanism to show a 3D model from any desired angle with which you can rotate the 3D model about all three axes in space having also a zoom and pan functionality - all just using the mouse. In addition, the *Analyst* enables geometric measurements directly taken on the 3D model. Dip direction and dip angle are measured by marking the appropriate location on the 3D model with the computer mouse. The same is possible for areas, distances, or point locations. Also included are instant previews of the measured orientations in a hemispherical plot and the determination of trace spacing. Furthermore, export functions and a report generator are integrated. Specifically, the *Analyst* is designed for the analyses of 3D models showing rock faces or terrain in a wide range of scale, such as tunnel faces, drift faces, caverns, rock slopes, quarries, open cut mines, or laboratory samples, as well as constructions, such as dams.

Attention:

Analyst reads files exclusively in **".jm3x"** file format. Models from previous versions in ".jm3" file format are not supported in the present version. Please note that ".jm3" files from previous versions can converted into a ".jm3x" file via the *ModelEditor.* See corresponding user manual for further information.

This user manual addresses all topics related to the *Analyst* i.e. user interface, 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 systems both, flexible enough for broad usage and sufficiently specific for your applications.

We wish you success with the *Analyst.*

The Team of 3GSM

Graz, August 2025

2   General

2.1   Capabilities

- The *Analyst* features the fast and detailed visualisation of single, multiple and merged 3D models. Following measurements so called *Annotation Elements* are provided in the software:

- Orientations (virtual compass – clinometer)

- Distances (virtual tape)

- Lineaments (trace & orientation)

- Areas & orientations

- Bridges (non-persistent elements)

- Co-ordinates (measuring points)

- Occurrences (water, single events)

- Partitioning of areas (lithology and homogeneous areas)

In addition the *Analyst* software includes the following geological and geotechnical peculiarities:

- Grouping of measurements into *Structure Sets*

- Semi-automatic trace detection

- Semi-automatic delineation of planar patches

- Automatic trace set clustering

- Spacing of traces including statistics

- Definition of analysis zones

- Orientation of traces including stereographic projection and statistics

- Scanline function

- Termination index

- Modelling of discontinuities

- Modelling of the direction of fractures

- Depth colouring of the 3D model

- Contour lines

- Discrimination of parts of the 3D model by a plane

- Mapping of lithologic regions and homogenous areas

- Visualization of displacement data

Data of the 3D model and corresponding *the Map* can be exported as:

- ".csv", ".dxf", ".vrml", ".obj" or plain text files and specific exports to *Rocscience* software

- Report as ".pdf" file and printout

See Chapter 2.4 and Chapter 9 for further information.

2.2 Annotations Elements and Tools

Once a 3D model is ready *Annotation Elements* can be placed directly on the model. *Annotation Elements* are organized in the software in individual groups i.e. *Structures*, *Geometry* and *Occurrences* and *Area Partitioning*. In addition, *Analyst* provides various *Tools* (e.g. hemispherical plots, automatic joint set clustering, definition of discontinuities, etc.) that accelerate the assessment of rock and terrain surfaces. The following information provides an overview of available features of the *Analyst.* A detailed description to each feature is found in individual chapters in this user manual.

Structures

Measurements:

- *Orientation*: Measurement of the spatial orientation of small surface patch around a freely placed position. Once it is set, the values for dip and dip direction are instantly available.

- *Trace*: Polygonal line in 3D that is used to map discontinuities, such as joint or strata

- *Guided Trace*: Automatic trace detection by clicking the start and end point. Similar to *Trace.*

- *Area*: Closed polygonal line used e.g. for mapping joint faces. Once it is set, the orientation of the area is given in terms of the mean *Orientation* of the surface normal.

- *Region Grow*: Closed polygonal lines enclosing automatically delineated planar patches. Similar to *Area.*

- *Bridge*: Direct connection between *Traces* for defining un-fractured parts of the rock mass

Zones & Scanlines:

- Zone:

    o *Analysis Zone*: Closed polygon which selects *Traces*, *Areas* and *Bridges* for *Trace Map Analysis*

    o *Exclusion Zone:* Closed polygon which defines regions in the *Analysis Zones.* Those regions are excluded from *Trace Map Analysis*.

- *Scanline*: Allows determining the spacing between *Traces* along an arbitrary defined scanline

Tools:

- *Discontinuity Model:* Planar geometric area that models the size and shape of a discontinuity. *Discontinuity Models* can be assigned to *Orientations*, *Traces* and *Areas*.

- *Discontinuity Surfaces:* Models the direction of a fractures and wavy discontinuities. *Discontinuity Surface* can be assigned to *Traces*.

- *Trace Map Analysis:* Shows data on *Trace* spacing and *Traces/Bridges* lengths

- *Stereonet Analysis:* Plots *Orientations* in a stereographic projection and displays the corresponding statistics

- *Clustering:* Groups *Structure Measurements* automatically into *Structure Sets*

- *Add Structure Set:* Adds a new *Structure Set* to the list

Note:
A *Discontinuity* can be modelled from parameters of single *Orientations*, *Traces* and *Areas.* See Chapter 4.11 for further information.

Note:
Annotation Elements of Geometry and *Occurrences* are organized within individual lists (*Volumes*, *Tapes*, *Measuring Points*, *Water*, etc.). Annotations cannot be moved between the different lists.

Note:
Structure Measurements (i.e. *Orientations*, *Traces*, *Areas* and *Bridges*) are grouped in so-called *Structure Sets,* which are shown on the right part of the *Analyst* window (within the *Structure List*). *Structure Measurements* can be moved between different *Structure Sets.*

Once a *Structure Set* contains more than two *Orientation / Trace* measurements, a statistical evaluation by a hemispherical plot, cluster plot and a spacing plot is shown.

Geometry

Measurements:

- *Volume:* Closed polygonal line enclosing volumes of moulds

- *Area Basic*: Closed polygonal line used e.g. for mapping joint faces. The *Area Basic* is a reduced version (limited functionality) of the *Area* measurement (see *Structure Measurements*).

- *Tape:*
    - Spatial and other projected distances between two points on the 3D model
    - Profile along the tape measure

- *Measuring Point:* Co-ordinates of a measured position; (x,y,z) or (E,N,H)

- *Section:* Planar polygon obtained by the intersection of the 3D model with an arbitrarily orientated cutting plane

Tools:

- *Contour Lines:* Displays the contour lines of the 3D model in a plan view

- *Cutoff Plane:* Discriminates parts of the 3D model by a plane

- *Depth Colouring:* Displays a false colour overlay on the surface of the 3D model for displaying irregularities

- *CSV 4D:* Displays movement (displacement) data imported from *Guardian - IDS GeoRadar*

Occurrences

- *Water*: Sphere pointing out water ingress

- *Punctual Occurrence*: Sphere pointing out single occurrences or events

- *Non-punctual Occurrence*: Polygonal line in 3D that is used to mark single non-punctual occurrences or events

Note:
Annotation Elements of *Geometry* and *Occurrences* are organized within individual lists (*Volumes*, *Tapes*, *Measuring Points*, *Water*, etc.). Annotations cannot be moved between the different lists.

Area Partitioning

- *Lithologic Region*: Closed polygonal lines used for mapping rock types on the 3D model

- *Homogeneous Areas*: Closed polygonal lines used for mapping regions with similar properties on the 3D model

Note:
Annotation Elements of Geometry, *Occurrences* and *Area Partitioning* are organized within individual lists (*Volumes*, *Tapes*, *Measuring Points*, *Water*, *Lithologic Regions*, etc.). Annotations cannot be moved between the different lists.

2.3 User interface

The user interface of the *Analyst* (Figure 1) comprises the menu bar, toolbar, 3D viewer, navigation bar and the *Mapping* pane. The *Mapping* pane contains four tabs: i.e. *Structures*, *Geometry, Occurrences, Area Partitioning and Settings*.
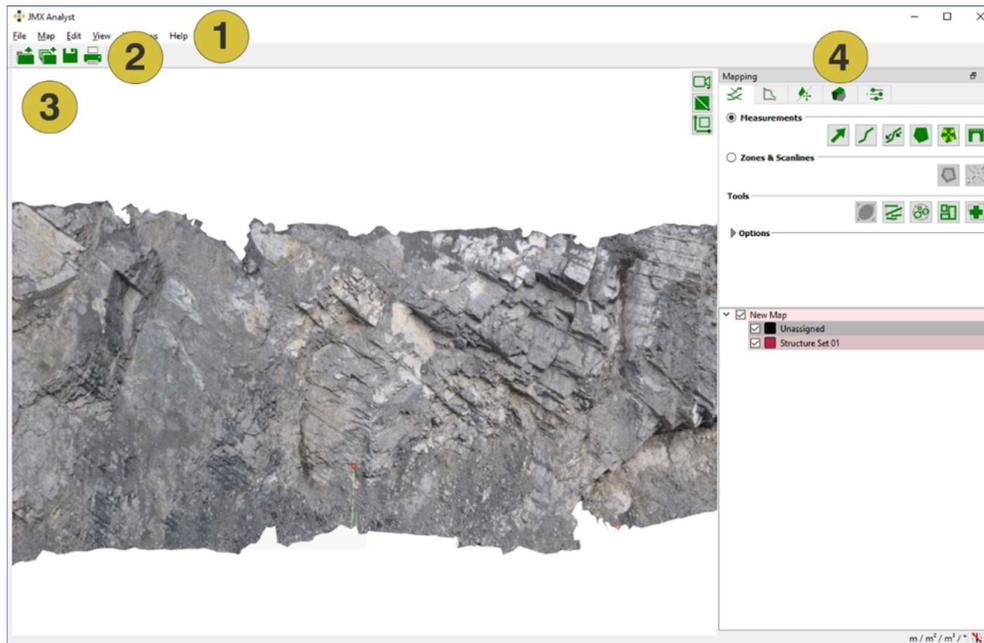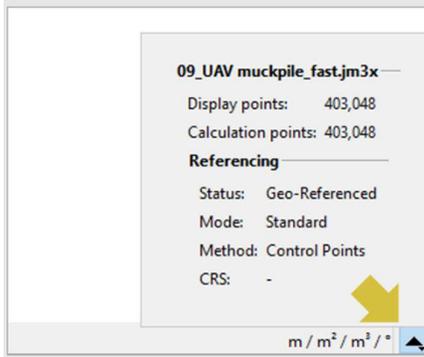

1   Menu bar
2   Toolbar
3   3D viewer
4   *Mapping* pane

Figure 1: Interface of the Analyst

Hint:

The unit of measurement is displayed on the right bottom of the user interface. The foldable dialog next to it displays information on the 3D model, i.e. geometry reproduction on the screen (adjustable via the Central Window Settings) and information on referencing and scaling.

2.4 File management

The *Analyst* software deals with two files:

1. The 3D model ("*.jm3x*" file) contains all information on the 3D model and its generation. It cannot be modified by the *Analyst* software.

2. *Annotation Elements* are stored in a so-called *Map* and saved into a separate file with the extension "*.jms*".

For file management follow the steps below:

- Open a 3D model by clicking "*Open 3D Model*" icon in the toolbar or using "*File | Open 3D Model*" from the menu bar: A dialog pops up asking for defining a "*.jm3x*" file.

- Open multiple 3D models subsequently by using "*File | Open Multiple 3D Models*" from the menu bar: A dialog pops up asking for defining one or several "*.jm3x*" files.

- Import a 3D model to the current one by using "*File | Import 3D Model*" from the menu bar: A dialog pops up asking for defining a "*.jm3x*" file.

- Open a *Map* by clicking the "*Load Map*" icon in the toolbar or using "*Map | Load Map*". A dialog pops up asking for defining a "*.jms*" file.

- Import a *Map* to the current one by using "*Map| Import Another Map*" from the menu bar. A dialog pops up asking for defining a "*.jms*" file.

- Save *Map* by clicking the "*Save Map*" icon in the toolbar or using "*Map | Save Map*" from the menu bar.

- Save a *Map* to a new file by using "*Map | Save Map as.*" from the menu bar

- Delete the *Map* or start a new evaluation by using "*Map | New Map*" from the menu bar.

- Exit *Analyst* by using "*File | Exit*" from the menu bar.

Hint:

Maps are automatically loaded in the *Analyst,* if the *Map* ("*.jms*" file") has the same file name as the 3D model ("*.jm3x*" file"). See also Chapter 3.10

Note:

The *Analyst* initiate a frequent backup-saving (10 minutes default – adjustable through "*Edit | Options*" in the toolbar; see Chapter 3.10). The original file has the extension "*.jms*" while the backup has the extension "*_sav.jms*".

3 Features

This section describes the available functions of the *Analyst*.

Attention:

By pressing *F1* on the keyboard tooltips for navigation as well as for editing annotations are available in the 3D viewer. The tooltips may differ in respect to the active item. Example:

Pan the view.	Add a point
Rotate the view.	Ctrl Insert a point
Zoom the view.	Alt Delete a point
Center view on position.	Shift Move a point
Alt Center and zoom.	Enter Finish editing
	Finish editing and add another Trace

3.1 Toolbar of the 3D viewer

3D View Options ▢

Move to Home Position

🏠   Sets the viewer to its initial position

View All

🔍 🔍   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

Projection type

■ ◀   Toggles between perspective and orthographic projection

Fullscreen

⬛   Switches between the fullscreen display and the windowed display

Mesh Draw Mode

Draw as is

The 3D topography is completely overlaid by the digital photograph

Wireframe

A triangulated red coloured point cloud is forming the topography

Wireframe Overlay

The 3D model and a red coloured overlay of the wireframe is forming the topography

Points

Th*e* point cloud of the scene shown

Show Texture   Displays the 3D model with texture in the viewer (shortcut key *"Ctrl" T*)

3D View Visibility

Show Reference Points	Shows or hides *Ground Control Points* used for referencing (*MultiPhoto*)
Show Axes	Turns the co-ordinate axes on and off
Show Bounding Box	Turns the bounding box surrounding of the 3D model on and off
Show Reference Plane	Shows or hides the *Reference Plane*
Show Contour Lines	Shows or hides contour lines on the 3D model

3.2 Navigation

Mouse navigation

Pan View

The middle mouse button is used to pan the 3D model

Rotate View

The right mouse button rotates the 3D model. Just keep the right button pressed and move the mouse around to see the 3D model rotating.

Zoom View

When turning the wheel of a mouse the 3D model is zoomed

Center View on Position

Centers to the current position

Center and Zoom

Pressing "*Alt*" and turn the mouse wheel centers the and zoom to the current position

Keyboard navigation

- Straight motion is performed by pressing the corresponding arrow key *"Left"*, *"Right"*, *"Up"* or *"Down"*.

- Zooming is performed by pressing *"Ctrl"* 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 with the corresponding arrow key *"Left"*, *"Right"*, *"Up"* or *"Down"*.

3.3   Menu bar

The menu bar comprises five menus. The menu commands are accessible using the mouse. The following paragraphs describe the structure and commands of the six menus (*File, Map, Edit, Windows* and *Help*).

Menu File

Open 3D Model	Opens a 3D model (".jm3x" file)
Open Multiple 3D Models	Opens multiple 3D models (".jm3x" files from one folder) one after the other

Import 3D Model	Imports another 3D model ("jm3x" file) to the current one
Export	

Export as VRML	Exports the 3D geometry and texture to a ".vrml" file
Export as DXF	Exports the 3D geometry (triangulation) to a ".dxf" file
Export as OBJ	Exports the 3D geometry and texture to an ".obj" file
Export for Rocscience (OBJ)	Exports the 3D geometry (mesh) and texture (ortho-photo) to ".obj"
Export for Rocscience (Point Cloud)	Exports the points of the 3D model (".3grs" file) and optionally structural-geologic data (".3gdps" file*)*
Export Points as CSV	Exports the points of the 3D model to a ".csv" text file (readable by spreadsheet programs)

Generate Screenshot	Generates a user-defined screenshot
Print Report	Prints a report to a connected printer
Export Report as PDF	Writes a report directly to a ".pdf" file
Exit	Closes the *Analyst*

Menu Map

New Map	Starts a new *Map* ("jms" file)
Load Map	Loads an existing *Map* ("jms" file)
Save Map	Saves the *Map* to the current ".jms" file
Save Map as	Saves the *Map* to a new ".jms" file
Import	

Import Another Map	Imports another *Map* to the current one

Export

Export to Dips	Export structural-geologic data to *Dips (".3gdps)*
Export Map as DXF	Exports the structures of the *Map* as ".dxf" file
Export Map as VRML	Exports the structures of the *Map* as ".vrml" file
Export Traces to Open Pit	Exports *Traces* to Open Pit (".csv" file)
Export Spacing Scanline Data as CSV	Exports *Scanline* data as ".csv" file
Export Structural Geologic Data	Exports structural geologic data as ".csv" file
Export Area Partitioning Data as CSV	Exports *Area Partitioning* data as ".csv" file
Export Discontinuity Models as CSV	Exports *Discontinuity* data as ".csv" file
Export Discontinuity Models as DXF	Exports *Discontinuity* data as ".dxf" file

Entitle Map	Allows editing and adding specific names and notes to the map

Menu Edit

Undo	Revokes the previously executed commands step by step
Redo	Redoes the commands revoked by the "*Undo"* function step by step
Options	Opens the *Options* dialog

Menu Windows

Reset Layout	Resets the layout of the *Analyst*
Mapping	Shows or hides the *Mapping* pane
Properties	Shows or hides the *Properties* pane
Plot	Shows or hides the *Plot* pane
Trace Map Analysis	Opens the *Trace Map Analysis* dialog
Stereonet Analysis	Opens the *Stereonet Analysis* dialog
Clustering	Opens the *Clustering* dialog
Contour Lines	Opens the *Contour Lines* dialog

Menu Help

User Manual	Opens the manual of the software component
Units	Displays the units used by the software
About	Displays versions and release information of the software component

3.4   Toolbar

Open 3D Model

Opens a 3D model (".jm3x" file)

Load Map

Loads an existing *Map* (".jms" file)

Save Map

Saves the *Map* to the current ".jms" file

Print Report

Prints the report

Undo

Revokes the previously executed commands step by step

Redo

Redoes the commands revoked by the "*Undo"* function step by step

3.5   Scrolling mechanism

The scrolling mechanism is a fast and easy way to change parameter values with the wheel of the computer mouse. Move the mouse cursor over the input field of the corresponding parameter and turn the mouse wheel (Figure 2). The entered numbers are highlighted and increase or decrease according to the spin of the wheel. Changed values are instantly updated.
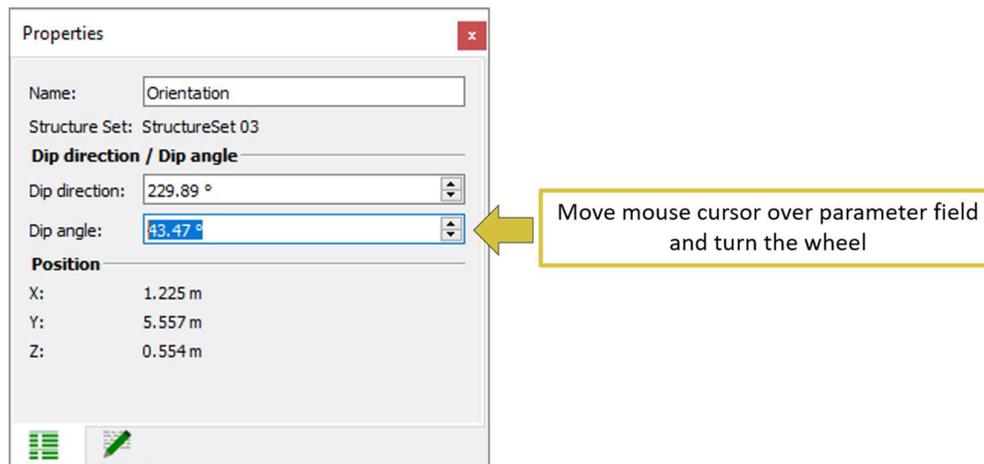
Figure 2: Scrolling mechanisms

3.6 Detachable panes

Analyst has three panes i.e. *Mapping, Properties* and *Plot,* which are requested from the menu *"Window"* or from the context menu of individual *Annotation Elements*. Panes can be attached and detached from the main window. The size and the shape of the panes can be adjusted with the mouse. Undocked panes can be placed on different screens. The layout of the user interface can be reset by selecting the menu *"Window | Reset Layout".* The viewer and the panes are arranged to its original layout.

Mapping pane

The *Mapping* pane (see Figure 3) comprises four tabs providing individual *Annotation Elements* and *Tools;* i.e. *Structure*, *Geometry*, *Occurrences* and *Area Partitioning.* The additional *Settings* tab allows the adjustment of the general mapping performance.
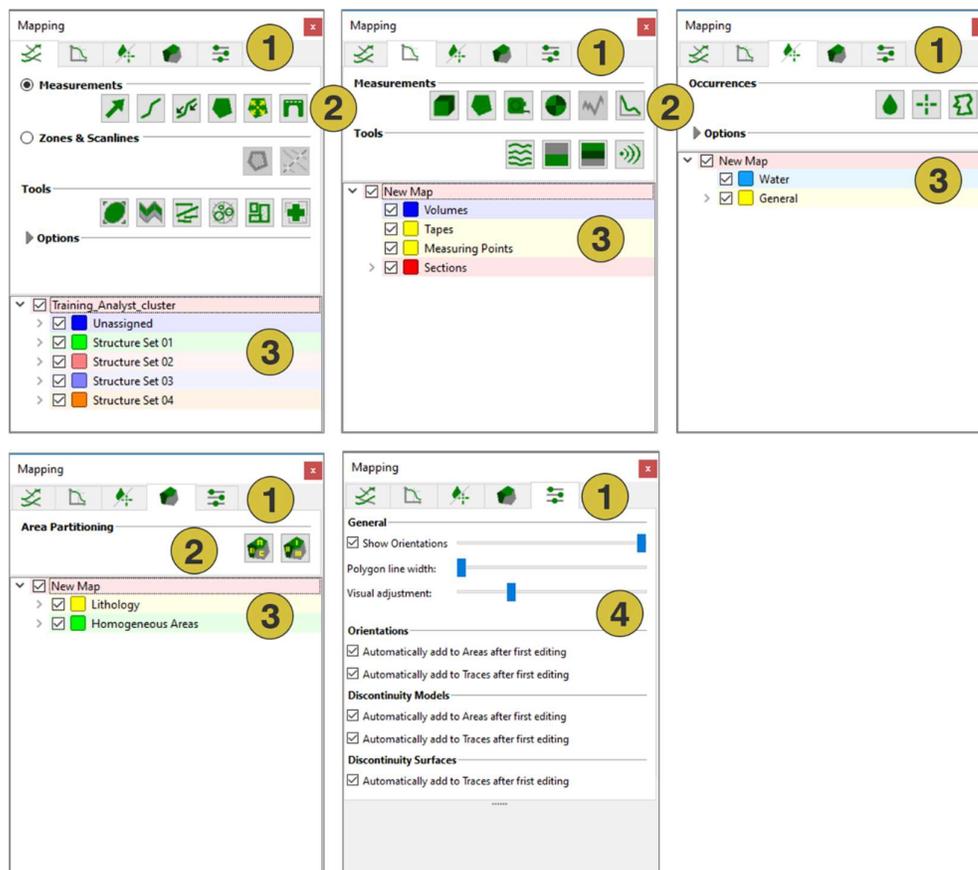
1   Individual tabs

2   Tab-specific toolbar

3   List of *Annotation Elements*

4   General settings

Figure 3: Mapping pane with individual tabs: Structure (top left), Geometry (top middle), Occurrences (top right), Area Partitioning (bottom left) and Settings (bottom middle)

Properties pane

The *Properties* pane displays the information of the selected *Annotation Element* (Figure 4). The layout of the pane depends on the selected element and is shown in the individual chapters in this manual.
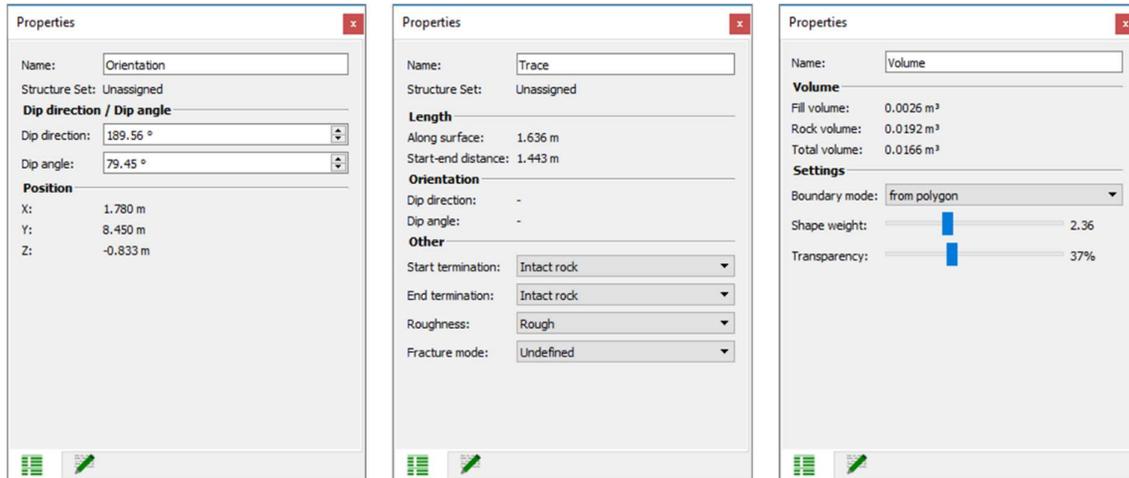

Figure 4: Examples of Properties panes

Note:

Notes can be added to each *Annotation Element* in the *Notes* ✐ tab in the *Properties* pane.

Plot pane

The *Plot* pane features the plot of the *Section*, *Tape Measure* and the *Profile* (profile plots along the surface), as well as plot of *Lithologic Regions* and *Homogeneous Areas* (pie charts). The specific *Plot* panes are shown in the corresponding chapter in this manual.

Attaching and detaching panes

Attaching and detaching panes serves for customising the layout of the *Analyst* and arranging panes with different functionality at your personal preference. A detachable pane has a dock bar at the top of its window (see Figure 3).

Attaching panes:

1. Drag the window of the detached pane close to your desired dock position.

2. A blue placeholder opens. Two options are possible:

   a. The placeholder can open a non-overlapping field (Figure 5)

   b. The placeholder can overlap with another view (Figure 6)

3. Once you release the left mouse button, the pane will dock to the place holder. In case of overlapping panes a flag at the pane´s bottom appears allowing switching between the panes.
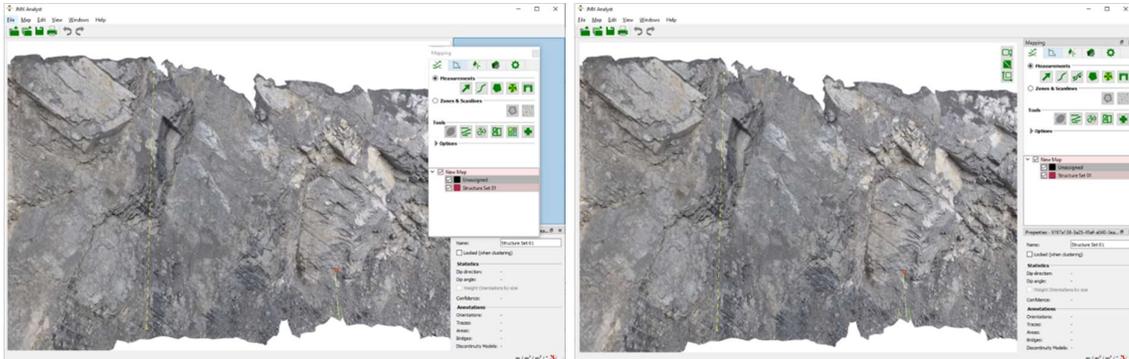

Figure 5: Attaching a pane into a non-overlapping placeholder. The pane docks and takes the shape of the placeholder after releasing the mouse button.
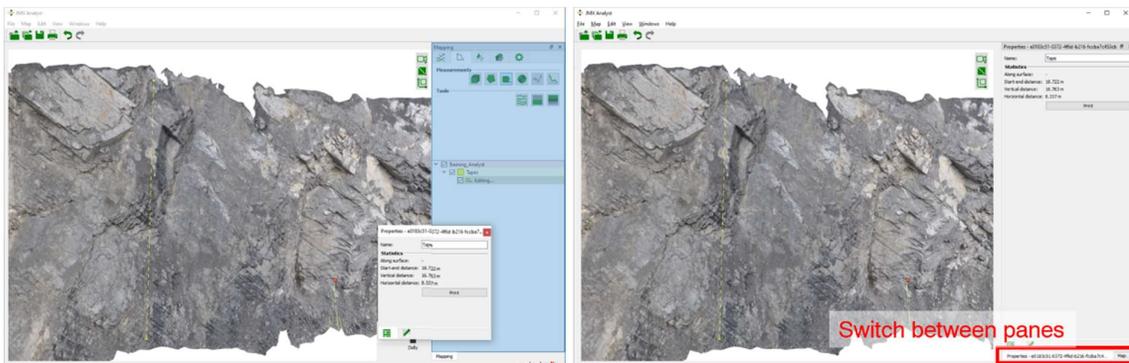

Figure 6: Attaching a pane into a placeholder overlapping with another pane. The pane docks and takes the shape of the placeholder after releasing the mouse button. A flag appears at the bottom of the view, which allows to switch between the overlapping panes.

Detaching panes:

1. Click with the left mouse button on the dock bar.

2. Drag the view to the desired position while holding the left mouse button (Figure 7).

Additional properties:

- Panes are shown or hidden through the menu "*Windows*" in the menu bar by selecting the corresponding entry.

- The size and shape of the pane scan be adjusted with the mouse by clicking at the pane´s boundary. The mouse cursor turns into a double arrow.

- Detached panes can be placed on different screens.

- The layout of the user interface can be reset with selecting the menu *"Windows | Reset Layout"*. The viewer and the panes are arranged to its original layout.
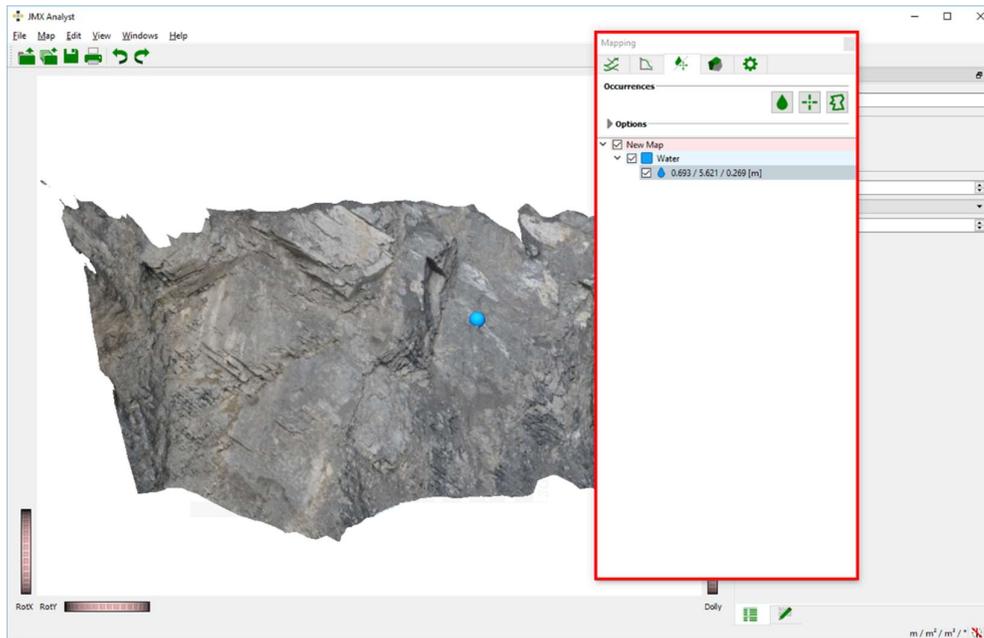

Figure 7: Detaching a pane with the mouse cursor in the dock bar while holding the left mouse button.

3.7   Mapping pane

The *Mapping* pane (see Figure 3) includes five tabs (i.e. *Structure*, *Geometry*, *Occurrences*, *Area Partitioning* and *Settings*) with tab-specific toolbars and options described below.

Structure ✖ **– Measurements**

Orientation

Adds an *Orientation*

Trace

Adds a *Trace*

Guided Trace   Adds a *Trace* by semi-automatic detection

Area

Sets the polygon of the *Area* boundary

Region Grow

Adds an *Area by* semi-automatic detection

Bridge

Adds an *Bridge* between two *Traces*

Structure – Zones & Scanlines

Zone

Adds *Zones (Analysis* or *Exclusion Zones)*

Scanline

Adds a *Scanline*

Structure – Tools

Add Discontinuity Model

Models the extent of a fracture by a finite plane

Add Discontinuity Surface

Models the direction of a fracture

Trace Map Analysis

Opens the *Trace Map Analysis* dialog for analyzing spacing and lengths of *Structure Measurements*

Stereonet Analysis

Plots the poles of measured *Orientations* in a stereographic projection

Clustering

Groups *Structure Measurements* into clusters

Add Structure Set

Adds a new *Structure Set*

Geometry – Measurements

Volume

Sets the polygon of the *Volume* boundary

Area Basic

Sets the polygon of the *Area Basic* boundary

Tape

Adds a *Tape* measurement

Measuring Point

Sets *Measuring Points*

Profile

Draws a vertical section (*Profile*) on the 3D model

Section

Draws a cutting plane on the 3D model

Geometry – Tools

Contour Lines

Generates contour lines of the 3D model

Cutoff Plane

Splits the 3D model into two regions along *a Cutoff Plane*

Depth Colouring

Shows the 3D model in false colours to show irregularities of the surface

CSV 4D

Imports Movement data from *Guardian – IDS GeoRadar* ("*.csv*")

Occurrences

Water

Adds a *Water* annotation

Punctual Event

Adds a *Punctual Event*

Non-Punctual Event

Adds a *Non-punctual Event* with a polygon

Area Partitioning

Lithologic Region

Adds an *Lithologic Region* on the 3D model

Homogenous Areas

Adds regions of *Homogenous Areas* on the 3D model

Settings

General
☑ Show Orientations
Polygon line width:
Visual adjustment:

Orientations
☑ Automatically add to Areas after first editing
☑ Automatically add to Traces after first editing
Discontinuity Models
☑ Automatically add to Areas after first editing
☑ Automatically add to Traces after first editing

General

- *Show Orientations (Object scale)*
  The scale of *Orientations* (arrows and semi-transparent joint planes) is set in this option by moving the slider

- *Polygon line width*
  The line width of polygons (e.g. *Traces*, *Areas*, *Tape,* etc.) is set in this option by moving the slider

- *Visual adjustment*
  The distance between drawn *Annotations Elements* and the 3D model can be adjusted my moving the slider. It only serves for visualization in the 3D viewer, measuring results are not affected.

Orientations

- *Automatically add to Areas after first editing*
  If this item is enabled, an orientation is added automatically to *Areas* after first editing

- *Automatically add to Traces after first editing*
  If this item is enabled, an orientation is added automatically to *Traces* after first editing. The orientation is only added if the points of the joint are not collinear.

Discontinuity Model

- *Automatically add to Areas after first editing*
  If this item is enabled, a discontinuity is added automatically to *Areas* after first editing

- *Automatically add to Traces after first editing*
  If this item is enabled, a discontinuity is added automatically to *Traces* after first editing

3.8 Management of lists

Annotation Elements are listed in tab-specific lists i.e. *Structure List* and individual list for *Volumes*, *Tape*s, *Measuring Points*, Profiles, *Sections*, etc. Per default, the checkbox on the left of an item is selected – i.e. the item is active and shown in the 3D viewer. When the checkbox is unselected, the element is deactivated (i.e. not involved in analysis) and hidden in the 3D viewer. Selecting the checkbox activates and shows the element again. By clicking the "*Hide/Show*" button the subordinated entries are hidden or shown (Figure 8). The left hand side of the list entry is shaded according to the selected colour for the *Structure Set*/*Annotation Element*. Analogue to the *Structure Sets* all other lists are managed in the same manner.
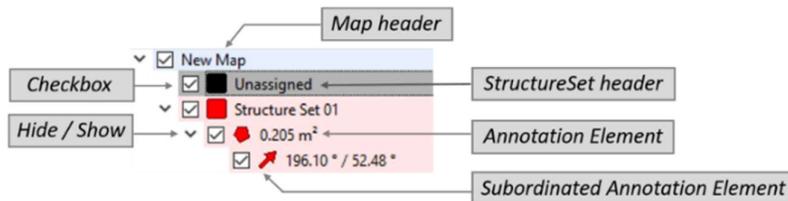

Figure 8: Scheme for Annotation Elements in the Structure List

3.9 Context menu of Annotation Elements

The context menu of individual *Annotation Elements* is called by selecting the desired item followed by a click on the right mouse button*.* Every *Annotation Element* has its own context menu according to its features. The same context menu also comes up in the 3D viewer selecting an *Annotation Element* with the left mouse button and pressing then the right mouse button. The context menus of the individual *Annotation Elements* are described at the corresponding chapters in this manual.

Context menu of multiple items

The context menu of multiple selected items comprises following features:

- *Set active*
  Activates (shows) and deactivates (hides) selected items

- *Set colour*
  Defines a new colour for selected items

- *Delete*
  Deletes selected items

- *Move to*

  Moves the selected items to another *Structure Set*

- *Export*

  Offers available export possibilities for selected items

Note:

"Set active" allows the user to hide or show the selected elements at once. In addition, the visualization of *Annotation Elements* can be controlled by filtering the length (*Traces*) or size (*Areas*) respectively.
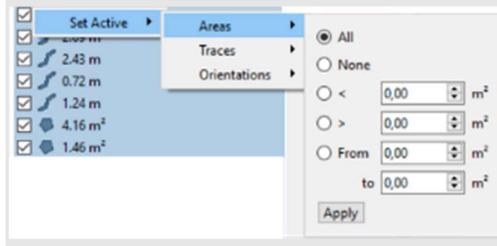
The multiple selection of items is proceeded as follows:

- Move the mouse cursor over the desired entries with the left mouse button clicked

- Perform individual clicks with the left mouse button while the *"Shift"* key is pressed

- Click with the mouse on an individual dataset and move the *"Move Down"* or *"Move up"* cursor on the keyboard while the *"Shift"* key is pressed

3.10 General options

The *Options* dialog (Figure 9) of the *Analyst* is called via the menu "*Edit | Options"*. It comprises the following features:

- *General*

  - *Automatically save every xx minutes*

    Security feature that automatically saves the ".jms" file". Automatic saving intervals in minutes can be chosen by the user.

  - *Automatically load Maps*

    Activates/deactivates the automatic loading of corresponding *Maps* (".jms" file") after loading a 3D Model. Note, the *Map* has to have the same file name as the 3D model.

  - *Ask before deleting multiple items*

    Security measure: The user is asked before deleting multiple selected items. Disabling deactivate the security measure; selected items are deleted immediately without any warning.

o *Default Map colour*

Defines the default colour of *Structure Sets*.

- *3D View*

o *Custom texture quality*

Changes the level of detail of the texture rendering on the screen form low to high. Note, enabling effects the texture quality in the *Analyst* software only. If the features is disabled, the texture quality is defined in the general settings (*Center Window Settings*).

o *Use original camera for home position*
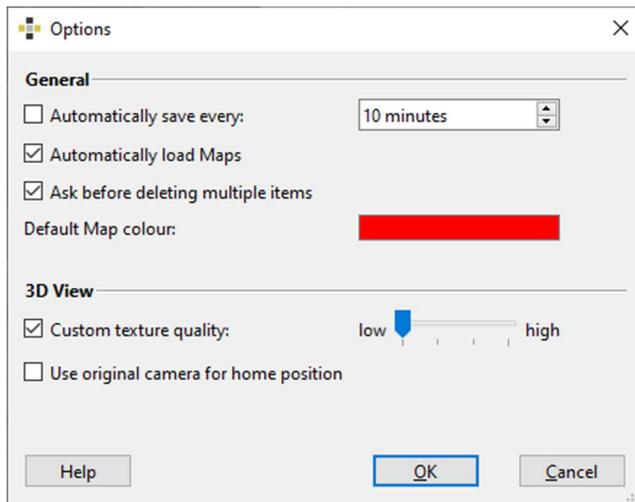
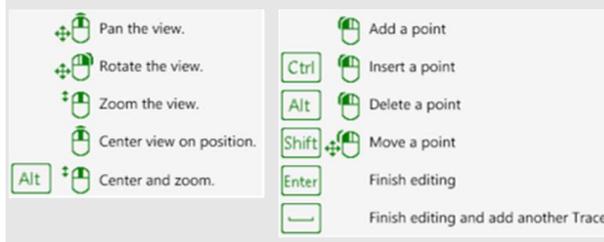Displays the 3D model in the viewer's home position from its original camera position.

Figure 9: Options dialog of the Analyst

3.11 Hints

Attention:

By pressing F1 on the keyboard tooltips for navigation as well as for editing annotations are available in the 3D Viewer. The tooltips may differ in respect to the active item.
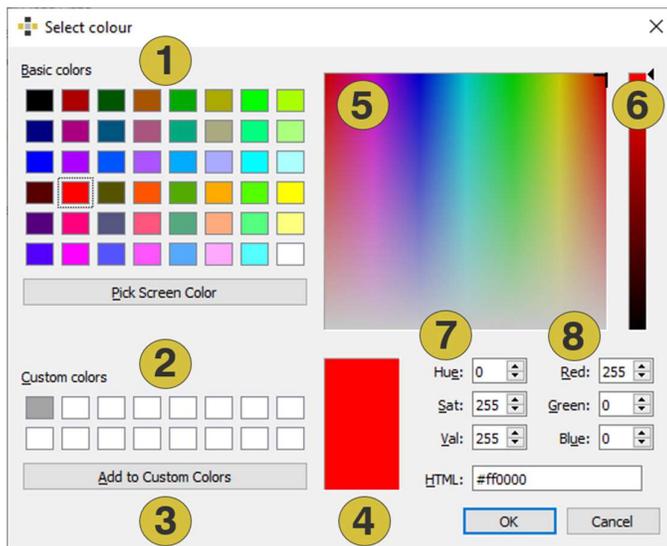
General

- Measurements are listed in the individual *Structure Sets* corresponding to their order in the toolbar, i.e. *Orientation*, *Trace*, *Area* and *Bridge*. *Discontinuity Models* are listed at the end.

- *Annotation Elements* are selected by clicking them either in the 3D viewer or within the individual lists. Selected elements are highlighted in both areas. Multiple selection of *Annotation Elements* is performed by holding "*Ctrl*" and clicking the left mouse button on the desired items. Multiple selection is possible within lists as well as in the 3D viewer.

- Customized notes are added to each *Annotation Element* by opening the *Notes* tab in the *Properties* pane.

- The current sub mode, i.e. *Annotation Element*, is terminated and a new one of the same type is started by pressing the "*Space"* key.

- A shortcut key function is assigned to each *Annotation Element* e.g. *O* for *Orientation*, *T* for *Trace*.

- Notification to each icon is gained by moving the cursor on its entry in toolbar.

- Notification to each *Annotation Element* in the 3D viewer is gained by holding "*Shift*" and moving the cursor on the item.

- The context menu of individual *Annotation Elements* is called by selecting the desired item followed by a click on the right mouse button*.*

- By default, the *Structure Set* and the *Annotation Elements* assigned are pointed out in the same colour in the *Structure List* as well as on the 3D model in the viewer. However, the colour of each element can be changed individually in the context menu by the user. The same may apply to all lists and corresponding elements in the *Analyst* interface.

- *Orientations* and *Discontinuities* are automatically added to *(Guided) Traces* and *Areas* after first editing by enabling the appropriate checkboxes in the *Settings* tab (*Mapping* pane).

- A new *Structure Set* is added to the *Structure List* by clicking "*Add Structure Set*" in the toolbar of the *Structure* tab of the *Mapping* pane.

- The default *Map* colour is defined in the general *Options* dialog called via the menu "*Edit | Options"*.

- The size and the shape of the panes can be adjusted with the mouse. Undocked panes can be placed on different screens. The layout of the user interface can be reset with selecting the menu "*Window | Reset Layout".* The viewer and the panes are arranged to its original layout.

Set colour

Individual colours can be defined for *Annotation Elements* in the context menu (see Chapter 3.9) by clicking "*Set Colour*". The Colour dialog (Figure 10) comprises a table showing basic colours, a table for custom colours (usually empty at the beginning), a colour mix field, a brightness bar, an editable colour value field and a display of the current colour. Confirming with the "*Ok*" button assigns the current colour to the individual item. The colour can be chosen from the basic colour table or can be customised. For customised colours use the colour mix field and the brightness bar by the use of the left mouse button. Alternatively, custom colours can be defined using the HSV and RGB editable fields. RGB refers to Red-Green-Blue values and can take values between 0 and 255. HSV refers to Hue-Saturation values. Hue can take values between 0 and 365 while the saturation and brightness can take values between 0 and 255. For further details refer to literature. The current colour can be copied to the custom colour table by clicking the "*Add to Custom Colour*" button.

1   Basic colours
2   Custom colours
3   Add current colour
4   Current colour
5   Colour mix field
6   Brightness bar
7   HSV colour data (editable)
8   RGB colour data (editable)

Figure 10: Colour dialog

4 Structures

4.1 General

The *Structure* tab comprises the *Option* dialog (Figure 11) with following features:

- *Show/Hide Orientations*
  Display of the *Orientations* (arrows and semi-transparent joint planes, see Chapter 4.3 and 4.4) in the 3D viewer activated or deactivated by the use of the checkbox

- Customized change of the object scale (slider)

- *Termination index*
  Defines the termination index by default to *Obscured*, *Intact rock*, *Discontinuity*
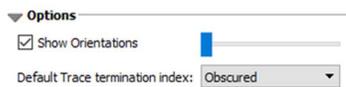
Figure 11: Options dialog for Structures

4.2 Structure Set

Structure Measurements (*Orientations*, *Traces, Discontinuities,...*) are grouped in so-called *Structure Sets*, which are shown within the *Structure List*.
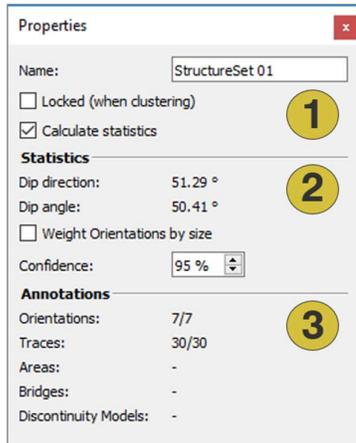
Properties

General information to each *Structure Set* is displayed in the *Properties* pane (Figure 12) which is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. The pane comprises the name of the active *Structure Set* which is editable in order to provide a descriptive name. Structures in the selected set are excluded (locked) for further clustering by enabling the corresponding checkbox "*Locked (when clustering)*" ☑ Locked (when clustering) .

Statistics

The statistics provides the mean orientation vector (dip direction and dip angle) of the *Structure Set*. The vector is the sum of all *Orientation* measurements contained in the *Structure Set* and divided by the number of measurements. This calculation assumes equal weights for each measurement and neglects the large *Traces* may have more impact on the mean set orientation than small *Traces*. The *Analyst* allows to enable weights for each measurements. The weights are related to the maximum diameter of the structure. In consequence, large structures have more impact on the mean set orientation than small structures. The mean orientation vector of a *Structure Set* is then the sum of all weighted *Orientation* measurements contained in the *Structure Set*. *"Weight Orientations by Size"* is enabled with the corresponding checkbox ☑ Weight Orientations by size .

Annotations

The pane provides the complete set of *Annotations Elements* i.e. *Orientations*, *Traces*, *Areas*, *Bridges* and *Discontinuity Models* (active annotations / total number of annotations) of the active *Structure Set*.

1   Settings

2   Statistics

3   *Annotation Elements*

Figure 12: Properties pane of individual Structure Sets

Adding a Structure Set

A new *Structure Set* is added to the *Structure List* by clicking "*Add Structure Set*" icon in the toolbar of the *Structure* tab of the *Mapping* pane.

Context menu

- *Set Colour*
  Defines a new colour for *Structure Set*

- *Delete*
  Deletes the *Structure Set*

- *Set active*
  Activates (shows) and deactivates (hides) selected items

- *Show Properties*
  Opens the *Properties* pane for the *Structure Set*

- *Export*

  o   *Export Structural-Geologic Data as CSV* Exports the structures of the set as ".csv" file

  o   *Export as DXF*   Exports the structures of the set as ".dxf" file

     ○ *Export as VRML*   Exports the structures of the set as "·vrml" file

- *New Structure Set*
  Adds an new *Structure Set*

4.3 Orientation

The feature allows freely placing an *Orientation* measurement on the 3D model showing its dip direction and dip angle instantaneously in the *Structure List* (Figure 13).

Standard operating procedure:

1. Activate "*Measurements*" in the toolbar of the *Structure* tab by clicking the corresponding radio button ⦿ **Measurements** .

2. Click on the "*Orientation*" ↗ icon or use the shortcut key *"O"*

3. Place the *Orientation* on the 3D model by clicking the left mouse button. Click left on the 3D model again to set the *Orientation* measurement to new position.

4. Finish the *Orientation* measurement and continue the mapping by pressing the "*Space"* key **or** finish the Orientation measurement by clicking "*Enter*" or by clicking the "*Orientation*" ↗ icon. Corresponding values are provided instantly by dip direction and dip angle in the *Structure List* (see Figure 13).

Edit the *Orientation* measurement by a double click with the right mouse button on the item and set a new position of the *Orientation* measurement by clicking the left mouse button.

Figure 13 shows the basic properties of individual *Orientation* measurements. An arrow visualises the upward normal vector of the measured orientation. The provided value is the mean orientation of the model surface formed by triangles underlying the base disc. Note that the base disc determines the minimum size for an *Orientation* measurement. Its size depends on the point density of the 3D model. The base disc is comparable to the compass flap of a Clar or Brunton compass. If the spike of the arrow is visible, the local surface dips towards the observer while the tail indicates an overhanging surface.

Figure 14 shows the shows the *Properties* pane for individual *Orientations*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Orientation*, information to which *Structure Set* the measurement belongs, the measured orientation (dip direction, dip angle) and the relative position. The name of the *Orientation* is editable in order to provide a descriptive name. Values corresponding to the *Orientation* measurement are editable in order to introduce manually determined orientations, for instance compass readings. Customized notes can be added to individual *Orientations* in the *Notes* ✎ tab.
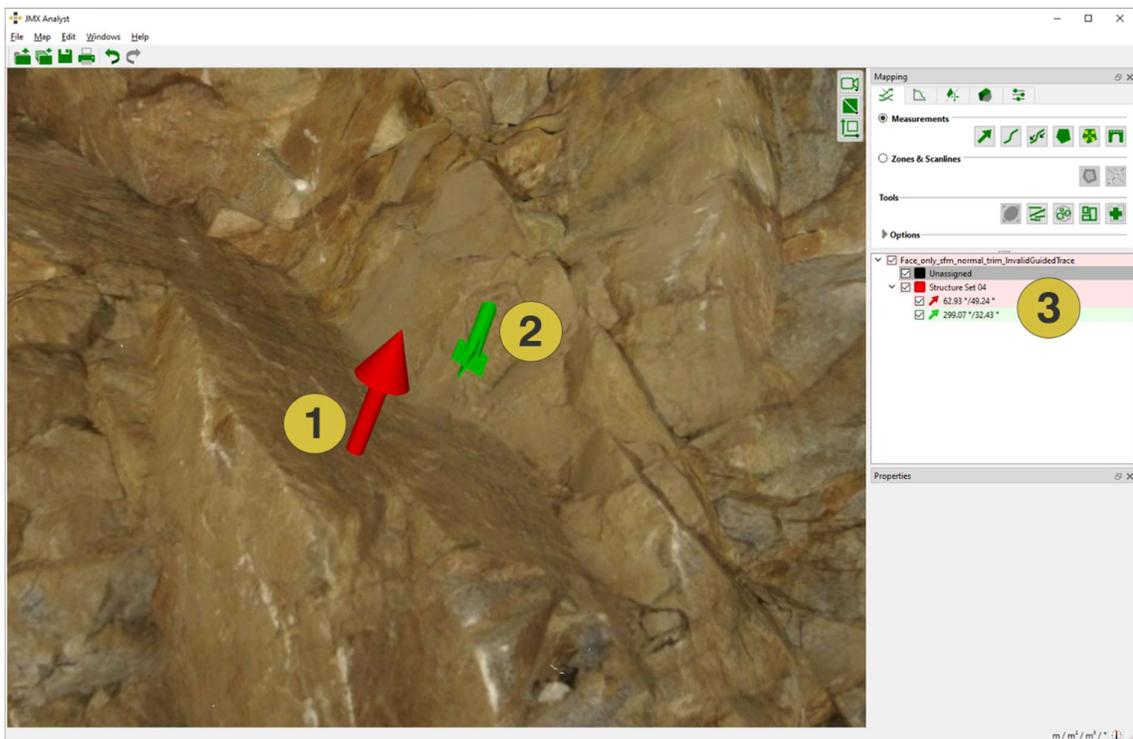
1   Arrow points in the direction of the upward surface normal vector

2   Tail indicates overhang

4   Dip direction and dip angle in the *Structure List*

Figure 13: Orientation measurement
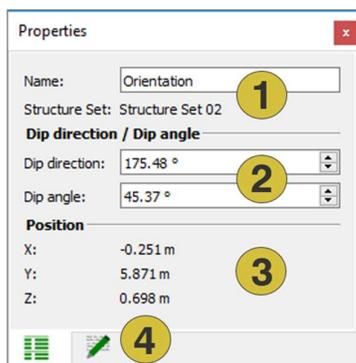
1   Name of the *Orientation* (editable) and *Structure Se*t

2   Dip direction and dip angle (editable)

3   Relative position

4   Notes (editable)

Figure 14: Properties pane for Orientations

Context menu:

- *Edit*

  Moves the *Orientation* to a new position defined by a click with the left mouse button. This function is disabled for subordinate *Orientations* (which are connected to *Areas* or *Traces*, see below).

- *Add Discontinuity Model*

  Models the extent of a fracture by a finite plane

- *Set Colour*

  Defines a new colour for the *Orientation*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Orientation* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Orientation* in the 3D viewer

- *Delete*

  Deletes the *Orientation*

- *Show Properties*

  Opens the *Properties* pane for the *Orientation*

- *Move to*

  Moves the *Orientation* to another *Structure Set*. This function is disabled for subordinate *Orientations*.

- *Export*

  - *Export Structural-Geologic Data as CSV* Exports the measurement as ".csv" file

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

4.4 Trace

The *Trace* mode is used for annotating lineaments. A *Trace* measurement is a polygonal line following the object surface in 3D space. Its length is provided in terms of the Euclidean distance and along the surface. The *Structure List* reveals the *Trace's* length along the surface. *Traces* are also used to determine the spacing of a *Structure Set*.

Standard operating procedure:

1. Activate "*Measurements*" in the toolbar of the *Structure* tab by clicking the corresponding radio button ⊙ **Measurements**

2. Click on the "*Trace*" 〰 icon or use the shortcut key "*T*"

3. Mark the *Trace* on the 3D model by clicking the left mouse button. A polygonal line is growing instantaneously.

4. Finish the *Trace* measurement and continue the mapping by pressing the "*Space"* key **or** finish the *Trace* measurement by clicking "*Enter*" or by clicking the "*Trace*" 〰 icon. The length of the *Trace* is provided instantly in the *Structure List* (see Figure 15).

Edit the *Trace* measurement by a double click with the right mouse button on the item:

- Add a point by clicking the right mouse button

- Insert a point by holding "*Ctrl*" and clicking the right mouse button

- Delete a point by holding "*Alt*" and clicking the right mouse button

- Move a point by holding "*Shift*" and clicking the right mouse button

Figure 15 shows a *Trace* measurement following the trace on the rock surface. If the measurement is active, the defined points are marked with squares. The figure also shows the obtained orientation (see below) as a semi-transparent plane. The values are displayed at the associated entry in the *Structure List*.

Figure 16 shows the *Properties* pane of *Traces*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. The pane comprises the name of the *Trace*, information to which Structure Set the measurement belongs, values on the length, the orientation of the joint plane (if determined), the termination index, roughness and the fracture mode. The name of the Trace can be edited in order to use an intuitive name or for more detailed descriptions. Customized notes can be added to individual Traces in the Notes 🖊 tab.

The termination index can be defined for the start and end points of the *Trace*. Following options are available:

- *Obscured*:   End of *Trace* is obscured by blocks, scree, vegetation, etc. or by extending beyond the limits of the exposed outcrop

- *Intact Rock*:   *Trace* terminates in intact rock material

- *Discontinuity*: *Trace* terminates at another discontinuity

The roughness is *undefined* by default. It can be defined as *very rough*, rough, *planar*, *curved* or *polished* in the *Properties* pane by using the corresponding pull down menu. In addition, the fracture mode is *undefined* by default. It can be defined as *Extensional*, *Shear (dextra*l) or *Shear (sinistral)* in the *Properties* pane by using the corresponding pull down menu. See Figure 16.
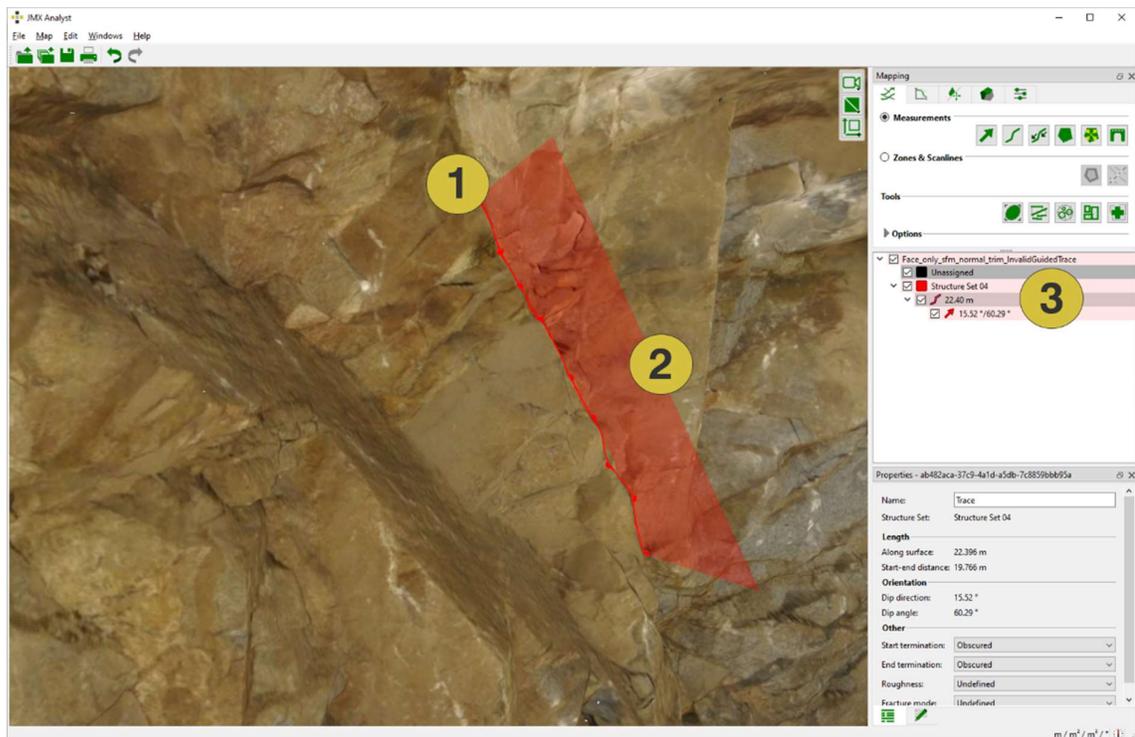
1   *Trace* follows the rock surface

2   Square indicates the plane forming the *Trace* and its orientation

3   Length along the surface, dip direction, and dip angle

Figure 15: Trace and it´s orientation. The joint plane is indicated by a semi-transparent plane which also delivers the orientation.

1 Name of the *Trace* (editable) and *Structure Set*

2 Length

3 Mean orientation of the *Trace*

4 Properties (editable)

5 Notes

Figure 16: Properties pane for individual Traces

Trace Orientations

If a *Trace* has sufficient variation in depth, a plane is fitted (least squares) and instantly visualised by a rectangle cutting through the 3D model. The *Orientation* given by dip direction and dip angle is instantly shown in the *Structure List*. If the *Trace* polygonal has not enough depth variation for a reliable plane fitting, no *Orientation* is provided.

Hint:

Always judge carefully for the plausibility of the *Orientation* of a *Trace* measurement as it is sensitive to the geometry of the polygonal, thus, uncertain sample locations of a joint trace might lead to uncertain orientation measurements.

Note:

Orientations are only automatically added to *Traces* if the *Setting "Automatically add orientation to joints after first editing"* is enabled (see Chapter 3.7. *Settings* tab).

Context menu:

- *Edit*
  Add a point by clicking the right mouse button. Insert a point by holding "*Ctrl*" and clicking the right mouse button. Delete a point by holding "*Alt*" and clicking the right mouse button. Move a point by holding "*Shift*" and clicking the right mouse button

- *Edit (guided)*

  Expands the active *Trace* with a *Guided Trace*(see Chapter 4.5) by clicking the end position on the 3D model with the left mouse button

- *Add an Orientation*

  Adds a subordinate orientation to the *Trace* (if not already present). This orientation is a part of the *Trace* and has only restricted possibilities for modification. Only one orientation can be added to a *Trace*.

- *Add Discontinuity Model*

  Models the extent of a fracture by a finite plane

- *Set Colour*

  Defines a new colour for the *Trace*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Trace* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Trace* in the 3D viewer

- *Delete*

  Deletes the selected *Trace*

- *Show Properties*

  Opens the *Properties* pane for the *Trace*

- *Move to*

  Moves the *Trace* to another *Structure Set*

- *Export*

  - *Export Structural-Geologic Data as CSV* Exports the measurement as ".csv" file

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

4.5   Guided Trace

The *Guided Trace* mode is used for annotating lineaments. It is a semi-automatic mode by clicking the start and end point of a joint trace. Image and graph processing algorithms provide the course of the trace and visualizes the trace on the 3D model. Its length is provided in terms of the Euclidean distance and along the surface. The *Guided Trace* comply with a *Trace* measurement and it is outlined as *Trace* in the *Structure List.* The *Structure List* reveals the *Guided Trace's* length along the surface. *Guided Traces* are also used to determine the spacing of a *Structure Set*.

Standard operating procedure:

1. Activate "*Measurements*" in the toolbar of the *Structure* tab by clicking the corresponding radio button ◉ **Measurements**

2. Click on the *"Guided Trace"* ✍ icon or use the shortcut key "*G*"

3. Add the start and the end point of the *Guided Trace* on the 3D model by clicking the left mouse button. A polygonal line surrounded by a cylinder is shown instantaneously on the 3D model. Optionally, insert a guidance point by holding "*Ctrl*" and clicking the left mouse button and delete the last added guidance point by holding "*Alt*" and clicking the right mouse button.

Hint:

Continue a *Guided Trace* by clicking the left mouse button on the 3D model during first editing or use the command *"Edit (guided)"* in the context menu after first editing. A polygonal line is growing instantaneously when clicking on the 3D model.

---

4. Adapt the course of the trace by adjusting the cylinder´s width (sphere of influence) by holding "*Shift*" and scrolling the mouse wheel. A narrow cylinder results in a straight trace, whereas the trace is allowed to deviate from a straight course by increasing the cylinder´s width (Figure 17).

5. Finish the *Guided Trace* measurement and continue the mapping by pressing the "*Space"* key **or** finish the *Guided Trace* measurement by clicking "*Enter*" or by clicking the "*Guided Trace*" ✍ icon. The length of the *Guided Trace* is provided instantly in the *Structure List* (see Figure 18).

Edit the *Guided Trace* measurement by a double click with the right mouse button on the item:

- Add a point by clicking the right mouse button

- Insert a point by holding "*Ctrl*" and clicking the right mouse button

- Delete a point by holding "*Alt*" and clicking the right mouse button

- Move a point by holding "*Shift*" and clicking the right mouse button

Figure 18 shows a *Guided Trace* measurement following the trace on the rock surface. If the measurement is active, the defined points are marked with squares. The figure also shows the obtained orientation (see below) as a semi-transparent plane. The values are displayed at the associated entry in the *Structure List*.

Figure 17: Adapting the cylinder`s with from narrow (left) to wide (right) by scrolling the mouse wheel
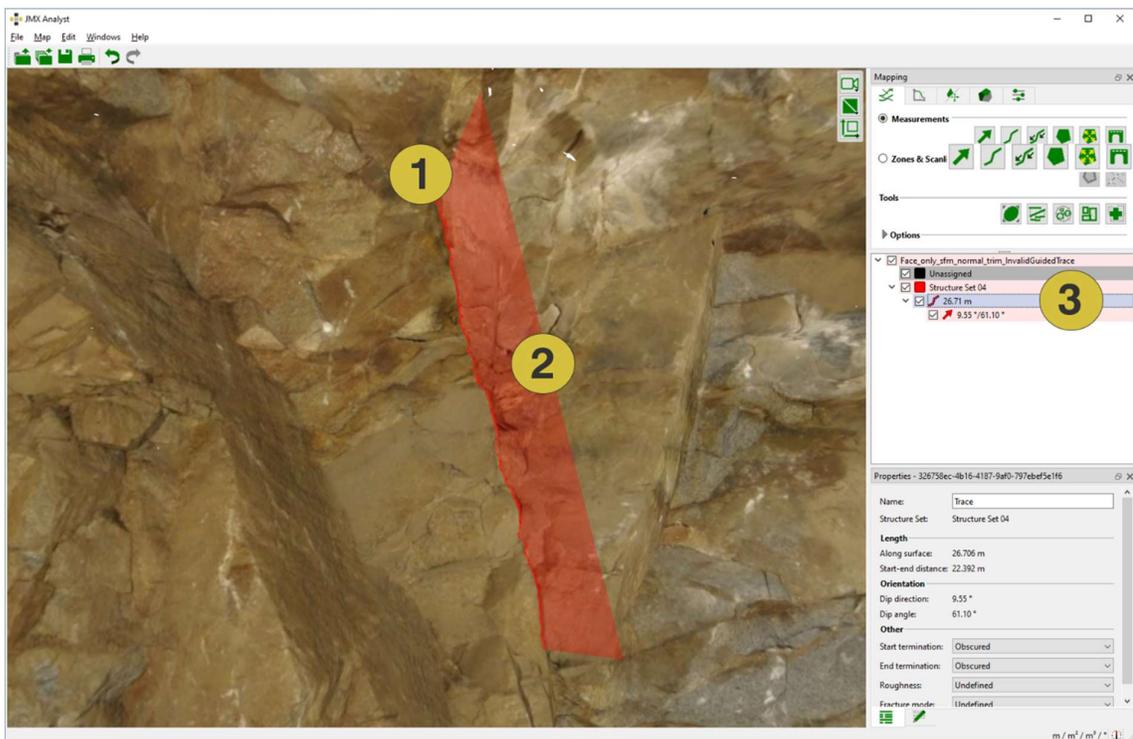
1   *Trace* follows the trace along the rock surface

2   Square indicates the plane forming the *Trace* and its orientation

3   Length along the surface, dip direction, and dip angle

Figure 18: Guided *Trace and it´s orientation. The joint plane is indicated by a semi-transparent plane which also delivers the orientation.*

Guided Trace Orientations

If a *Guided Trace* has sufficient variation in depth, a plane is fitted (least squares) and instantly visualised by a spatial rectangle cutting through the 3D model. The *Orientation* given by dip direction and dip angle is instantly shown in the *Structure List*.

Hint:

Always judge carefully for the plausibility of the *Orientation* of a *Guided Trace* measurement as it is sensitive to the geometry of the polygonal, thus, uncertain sample locations of a joint trace might lead to uncertain orientation measurements.

Note:

Orientations are only automatically added to *Guided Traces* if the *Setting "Automatically add orientation to joints after first editing"* is enabled (see Chapter 3.7. *Settings* tab).

The *Properties* pane and the context menu for the *Guided Trace* are identical as for *Traces* and is described in Chapter 4.4 (see Figure 16).

4.6 Area

The *Area* mode is used for annotating area based structures (e.g. discontinuity surfaces) or for regions of common geological attributes. An *Area* consists of a closed polygonal line that follows a discontinuity surface or any arbitrary portion of the surface (Figure 19). The size of the *Area* is provided in terms of the rough area in the *Structure List. Areas* are also used to determine the spacing of a *Structure Set*.

Standard operating procedure:

1. Activate "*Measurements*" in the toolbar of the *Structure* tab by clicking the corresponding radio button ◉ Measurements

2. Click on the *"Area"* 🟢 icon or use the shortcut key "*A*"

3. Map the border line of the *Area* 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).

4. Finish the *Area* measurement and continue the mapping by pressing the "*Space"* key **or** finish the *Area* measurement by clicking "*Enter*" or by clicking the "*Area"* 🟢 icon. The *Area* is automatically closed, shaded and the orientation is added; i.e. mean *Orientation* of the surface normal (see Figure 19). The size of the *Area* is provided in terms of the rough area in the *Structure List.*

Edit the *Area* measurement by a double click with the right mouse button on the item:

- Insert a point by holding "*Ctrl*" and clicking the right mouse button

- Delete a point by holding "*Alt*" and clicking the right mouse button

- Open the area by holding "*Alt*" and clicking the right mouse button and a click on the polygon

- Move a point by holding "*Shift*" and clicking the right mouse button

Hint:

If the size of an *Area* gets significantly small, the orientation values can get uncertain. The software provides a warning in this case asking whether to "*Keep*" or "*Delete*" the *Area*.
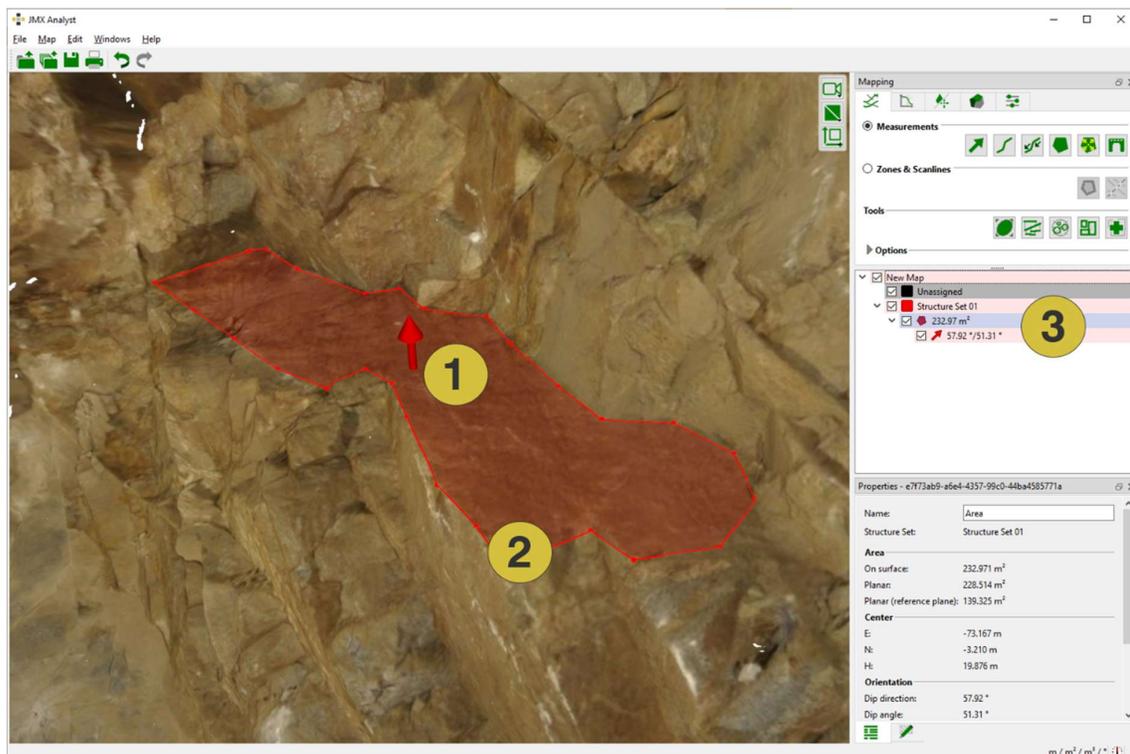
1 Mean upward normal vector of the *Area*

2 Clicked polygon follow the surface of the 3D model

3 Size of *Area* (rough) with assigned mean dip direction and dip angle in the *Structure List*

Figure 19: An Area drawn over a joint surface. The enclosed area is displayed and shaded. The software determines instantly the size and the mean orientation of the surface normal, i.e. the orientation values dip direction and dip angle.

Figure 20 shows the *Properties* pane of *Areas*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. The pane comprises the name of the *Area*, information to which *Structure Set* the measurement belongs and the type of *Area*. In addition the (rough) size the planar size, the orientation of the joint plane (if determined), the co-ordinates of the centroid, roughness, fracture mode and the growing distance is given. The name of the *Area*s can be edited in order to use an intuitive name or for more detailed descriptions. Customized notes can be added to individual *Areas* in the *Notes* 🖉 tab.

The roughness is *undefined* by default. It can be defined as *very rough*, *rough*, *planar*, *curved* or *polished* in the *Properties* pane by using the corresponding pull down menu. In addition, the fracture mode is *undefined* by default. It can be defined as *Extensional*, *Shear (dextral)* or *Shear (sinistral)* in the *Properties* pane by using the corresponding pull down menu. See Figure 20.

Note:

An *Area* can be extended automatically by adding a growing area in the context menu by selecting *Edit (Region Grow)*. See Chapter 4.7 for further information.

Note:

Orientations are only automatically added to *Areas* if the *Setting "Automatically add orientation to areas after first editing"* is enabled (see Chapter 3.7, *Settings* tab).
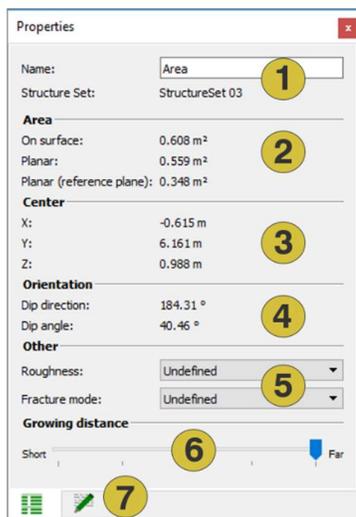
1 Name of the *Area* (editable) and *Structure Set*

2 Size

3 Centroid

4 Mean *Orientation*

5 Roughness and fracture mode (editable)

6 Growing distance (editable)

7 Notes (editable)

Figure 20: Properties dialog for Areas

Area size vs. planar Area size

The *Area* measurement provides three numbers for the area size:

- The *Area Size on Surface* refers to the spatial area, i.e. the sum of triangles enclosed by the area's polygon

- The *Planar Area Size* refers to the area obtained by projecting the border polygon onto a projected plane calculating the planar area enclosed by the projected polygon. The projected plane is defined by the mean plane fitted to the clicked points. Figure 21 gives an overview of the relationships.

- The *Planar Area Size* related to the *Reference Plane* refers to the area obtained by projecting the border polygon onto the *Reference Plane* calculating the planar area enclosed by the projected polygon. The *Reference Plane* is automatically defined by the software when generating the 3D model ("jm3x").
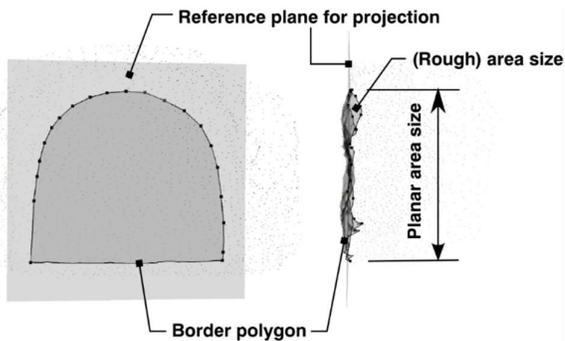
Figure 21: Definition of Area size On Surface and the Planar Area size

Context menu:

- *Edit*
  Insert a point by holding "*Ctrl*" and clicking the right mouse button. Open the *Area* holding "*Alt*" and clicking the right mouse button. Move a point by holding "*Shift*" and clicking the right mouse button.

- *Edit (Region Grow)*
  Adds a *Growing Region* to the existing *Area* (see Chapter 4.7)

- *Reduce Points*
  Reduces the number of clicked points of the polygon. This is useful when modifying automatically determined areas with the region grow (see next chapter for further details).

- *Add an Orientation*
  Adds a subordinate orientation to the *Area*. This orientation forms part of the *Area* measurement and has only restricted possibilities for modification. Only one orientation can be added to an *Area*.

- *Add Discontinuity Model*
  Models the extent of a fracture by a finite plane

- *Set Colour*
  Defines a new colour for the *Area*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Area* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Area* in the 3D viewer

- *Delete*

  Deletes the selected *Area*

- *Show Properties*

  Opens the *Properties* pane for *Areas*

- *Move to*

  Moves the *Area* to another *Structure Set*

- *Export*

  - *Export Structural-geologic Data as CSV*   Exports the measurement as ".csv" file

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

4.7   Bridge

Bridges allow marking intact rock bridges between interrupted *Traces* (Figure 22). The start and end points of *Bridge* measurements are limited to the start and end points of the *Traces*. There have to be at least two *Traces* within the same *Structure Set* to mark a *Bridge*. *Bridges* are used for calculating persistence.

Standard operating procedure:

1. Activate "*Measurements*" in the toolbar of the *Structure* tab by clicking the corresponding radio button ⊙ **Measurements**

2. Click on the "*Bridge*" 🖽 icon or use the shortcut key "*B*"

3. Mark the end point of a *Trace* with a left button mouse click

4. Mark the start point of the *Trace* to connect with by clicking the left mouse button

5. Finish the *Bridge* measurement and continue the mapping by pressing the "*Space*" key **or** finish the *Bridge* measurement by clicking "*Enter*" or by clicking the "*Bridge*" 🖽 icon. The *Bridge's* length (along the surface and the start-end distance) is displayed instantly in the *Structure List* (see Figure 22).
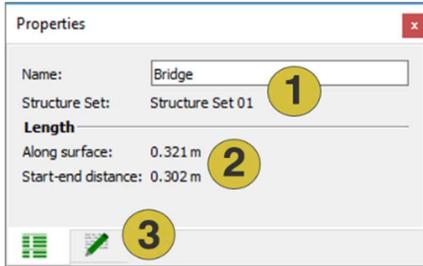
Edit the *Bridge* measurement by a double click with the right mouse button on the item and move the points of the *Bridge* measurement to another *Trace* by clicking the right mouse button.

Figure 23 shows the *Properties* pane for *Bridge*s. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Bridge*, information to which *Structure Set* the measurement belongs and values for the lengths. The name of the *Bridge* can be edited in order to use an intuitive name or for more detailed descriptions. Customized notes can be added to individual *Bridges* in the Notes 🖉 tab.
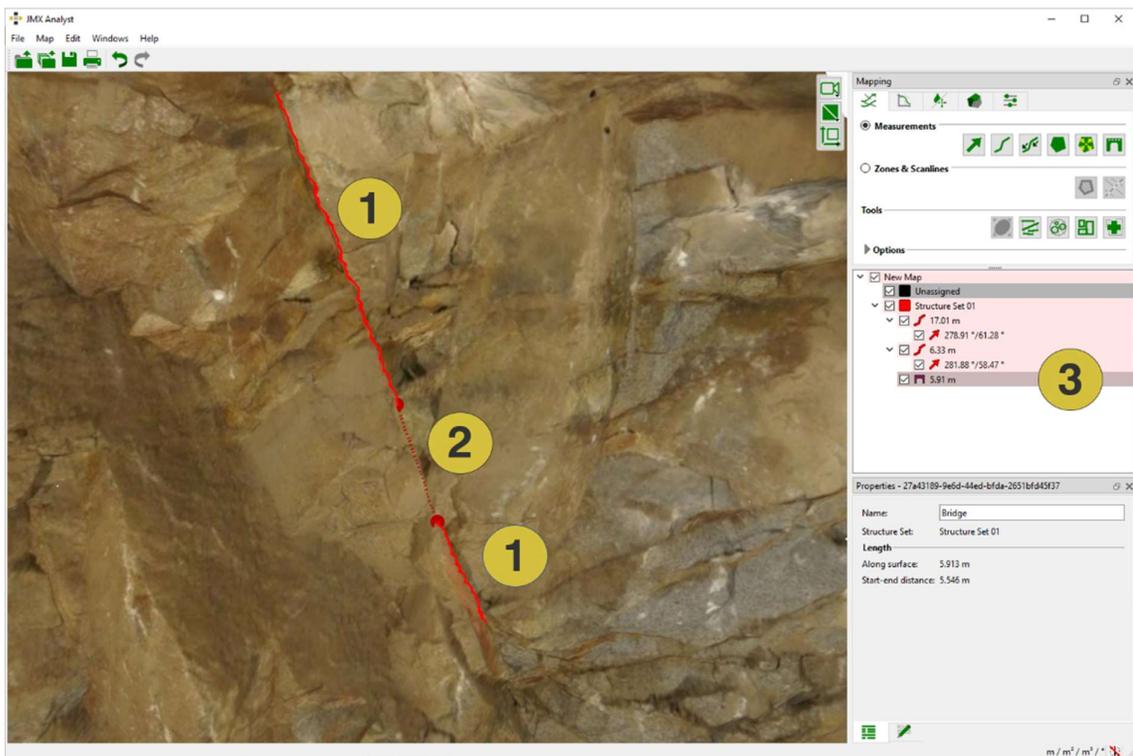
1 *Traces* (solid line)
2 *Bridge* (dotted line)
3 Length (along surface and start-end distance)

Figure 22: A discontinuity Bridge connects two Traces. It is displayed as a dotted line.

1   Name of the *Bridge (editable)*

2   Length of Bridge

3   Notes (editable)

Figure 23: Properties pane for Bridge

Context menu:

- *Edit*

  Moves the points of the *Bridge* measurement to a new *Trace* by clicking the right mouse button

- *Set Colour*

  Defines a new colour for the *Bridge*

- *Look at*

  Centers the *Bridge* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Bridge* in the 3D viewer

- *Delete*

  Deletes the selected *Bridge*

- *Show Properties*

  Opens the Properties pane for the *Bridge*

- *Move to*

  Moves the *Bridge* to another *Structure Set*

- *Export*

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

4.8   Region Grow

The *Region Grow* mode is used for annotating area based structures (e.g. discontinuity surfaces). It is a semi-automatic mode intended to discriminate planar patches on the 3D model. A *Region Grow* consists of a closed polygonal line that follows a discontinuity surface or any arbitrary portion of the surface. The size of the *Region Grow* is provided in terms of the spatial area in the *Structure List.*

Attention:

A *Region Grow* is outlined as *Area* in the *Structure List.*

Standard operating procedure:

1. Activate "*Measurements*" in the toolbar of the *Structure* tab by clicking the corresponding radio button ◉ **Measurements**

2. Click on the "*Region Grow*" 🔲 icon or use the shortcut key "*R*"

3. Click on an arbitrary point (seed point) on the 3D model with the left mouse button and

   a. desire the extension of the *Region Grow* (Sphere of Influence outlined as a planar patch around the seed point) holding "*Shift*" and moving the mouse up (increase the extension) or down (decrease the extension) on the 3D model.

   b. desire the *Growing Distance* by holding *"Ctrl"* and moving the mouse up (far) or down (short) on the 3D model.

4. Release the mouse and an area automatically pops up enclosing a planar patch (see Figure 24)

5. Expand the *Region Grow* by holding "*Ctrl*" and clicking outside the polygon on the 3D model with the left mouse button.

5. Finish the *Region Grow* measurement and continue the mapping by pressing the "*Space"* key **or** finish the *Region Grow* measurement by clicking "*Enter*" or by clicking the "*Area*" 🔲 icon. The *Region Grow* is automatically shaded and the *Orientation* (i.e. mean orientation of the surface normal) is added (see Figure 24). The size of the *Region Grow* is provided in terms of an *Area* the *Structure List.*

Edit the *Region Grow* measurement by a double click with the right mouse button on the item:

- Insert a point by holding "*Ctrl*" and the clicking right mouse button

- Delete a point by holding "*Alt*" and the clicking right mouse button

- Open the area by holding "*Alt*" and the clicking right mouse button and a click on the polygon

- Move a point by cli holding cking "*Shift*" and the clicking right mouse button

Attention:

If the polygon cannot be closed at a certain position, the area will be outlined as "*Invalid Area*" in the *Structure Set* list. The position is highlighted by a yellow spot in the 3D viewer and the position has to be

adapted by the user to finish the area measurement.
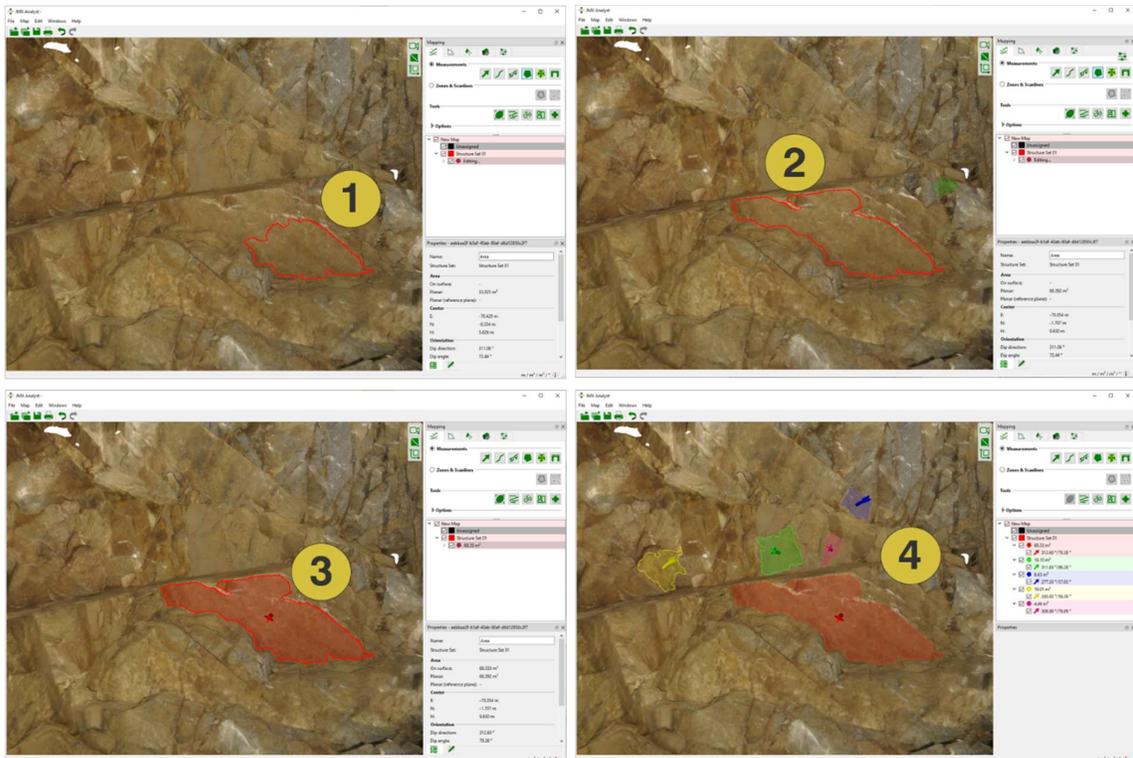

Figure 24: Region Grow: Region is defined by a polygon (1). Joint planes not perfectly planar may require extension of the Region Grow by defining additional seed points (2). Accepted region is automatically shaded and the normal vector of the area is displayed (3). 3D model assessed with several Region Grows (4).

Hint:

If the size of an *Area* (*Region Grow)* gets significantly small, the orientation values can get uncertain. The software provides a warning in this case asking whether to "*Keep"* or "*Delete"* the *Area* (*Region Grow)*.

The *Properties* pane for the *Region Grow* is identical as for *Areas* and is described in Chapter 4.5 (see Figure 20).

Characteristics of a Region Grow

The anatomy of a *Region Grow* is identical to the one of the *Area*. In contrast, it uses an ingenious algorithm to discriminate planar patches around seed points. The seed point is a point on the 3D model which has been defined by the left mouse button. An initial orientation is assigned to the seed point. The surrounding of the seed point is considered as planar if it complies with two criteria:

- The mean orientation of the subset must not deviate a certain angle from the initial seed point orientation

- The location of the subset must not be located at a certain offset from the seed point location

Rock surfaces are usually non-planar, i.e. they show a certain roughness or curvature. The criteria have been calibrated to enable the *Region Grow* function for a wide set of different rock mass properties.

Consideration of local roughness of the region

The roughness of the region influences the effectiveness of the planarity criteria. It is possible to control the size of the volume in which the roughness is sampled. In general and for best results, the sampled volume should stand for the global roughness of the analysed regions.

Sampling of region roughness

If the user clicks the seed point on the region and a green sphere appears (e.g. Figure 25 top left). The green sphere indicates the volume used for sampling the region roughness. Regions of the 3D model inside the green sphere are used for deriving the roughness. The sphere can be downsized or enlarged by holding "*Ctrl*" and scrolling the middle mouse wheel Figure 25 bottom shows a downscaled sphere and the corresponding result of the *Region Grow* and an enlarged sphere and the corresponding result of the *Region Grow*. The *Region Grow* is launched once the left mouse button has been clicked.
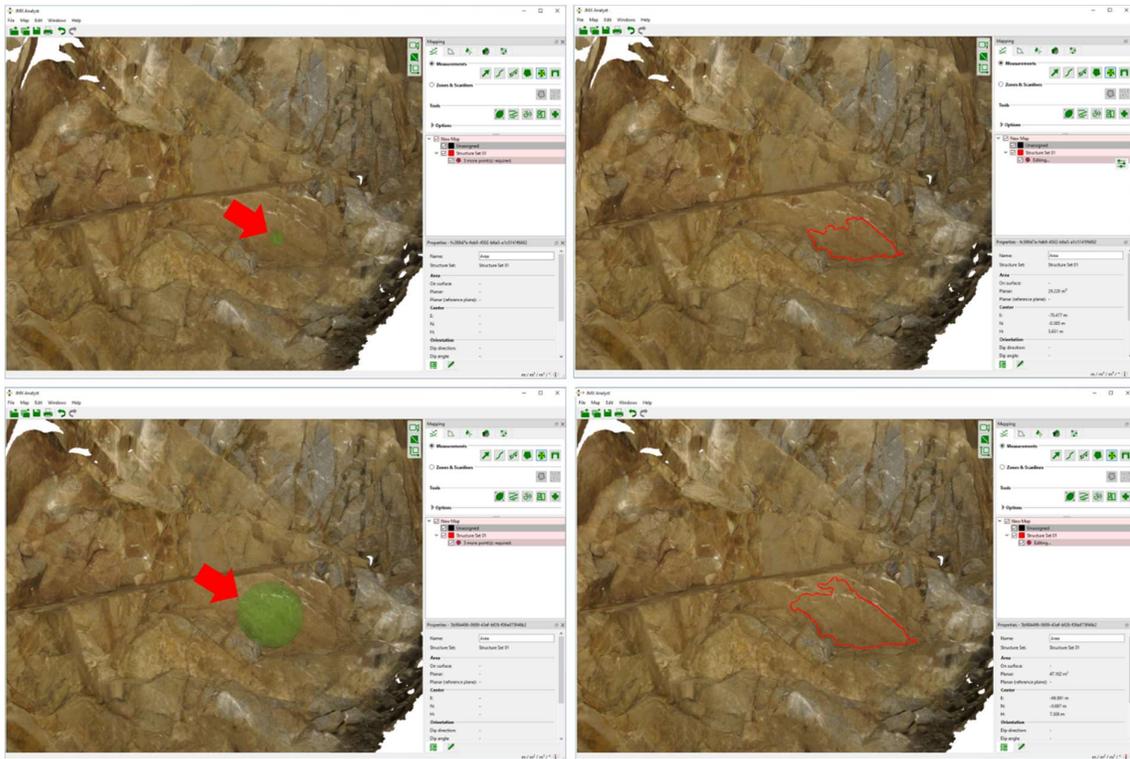
Figure 25: Downscaled (top) and enlarged (bottom) roughness sampling volume and corresponding results

Growing Distance

The *Growing Distance* is controlled by an insert which appears upon activating the "*Region Grow*" in the *Properties* pane or by holding "*Ctrl*" and scrolling the mouse wheel. The user can select five levels between "*Short*" and "*Far*". The *Growing Distance* influences the thresholds applied for the planarity criteria (orientation and offset criteria). Figure 26 shows the results for automatically grown area with a "*Short*", intermediate, and "*Far*" *Growing Distance*.

Note:

The modification of the *Growing Distance* is indicated by polygon visualized together with the sphere of influence during editing. A straight polygon indicates a short *Growing Distance* whereas a stepwise curved one indicates an increased *Growing Distance* (intermediate too far).

Figure 26: Region Grow with different Growing Distances: short (top left), intermediate (top right), far (bottom left).

The context menu of the *Region Grow* is identical to the context menu of the *Area* and is described in Chapter 4.5.

4.9 Zone

The *Analyst* features the definition of *Zones*, i.e. *Analysis Zones* and *Exclusion Zones*. *Analysis Zone*s are closed polygons drawn by the user on the 3D model which selects or excludes *Areas*, *Traces* and *Bridges* intersected or surrounded by the polygon. *Analysis Zones* are used to create subsets of *Structure Sets* for further *Trace Map Analysis* (see Chapter 4.11). *Exclusions Zones* a closed polygons which exclude regions from analysing spacing parameters. Those zones may be areas of limited information (e.g. obstructed zones, vegetation, muck-covered zones, etc.) which affect *Trace Map Analysis. Analysis Zone*s outlined as dashed lines and whereas *Exclusion Zones* are outlined as dotted lines in the 3D viewer. Both *Zones* are managed in an individual list (called *Zones*) in the *Structure* tab of the *Mapping* pane.

Standard operating procedure:

1. Activate *"Zones & Scanlines"* in the toolbar of the *Structure* tab by clicking the corresponding radio button ⊙ **Zones & Scanlines**

2. Click on the *"Zone"* icon or use the shortcut key *"Z"*

3. Mark the border line of the *Zone* 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).

4. Finish the *Zone* and continue the mapping by pressing the "*Space"* key **or** finish the *Zone* by clicking "*Enter*" or by clicking the "*Zone*" icon. The *Zone* is displayed instantly in the corresponding list in the *Structure* tab.

5. Define the *Zone* as *"Analysis Zone"* or *"Exclusion Zone"* in the *Properties* pane by clicking the desired radio button (see Figure 27 and Figure 28)

Edit the *Zone* by a double click with the right mouse button on the item:

- Insert a point by holding "*Ctrl*" and clicking the right mouse button

- Open the *Zone by* holding "*Alt*" and clicking the right mouse button

- Move a point by holding "*Shift*" and clicking the right mouse button

Hint:

By default, *Zones* are outlined as red (dashed or dotted) lines in the 3D viewer. Recolouring of *Zones* is performed in the context menu by a click on "*Set Colour*".

Figure 28 shows the shows the *Properties* pane of *Zones*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Zone* and the type of *Zone* (i.e. *Analysis* or *Exclusion Zone*). In addition, *Zone* are activated or deactivated for *Trace Map Analysis* in the individual *Structure Sets* by using the checkbox "*Apply*. The name of the *Zone* is editable in order to provide a descriptive name. Customized notes can be added to individual *Zones* in the *Notes* tab.
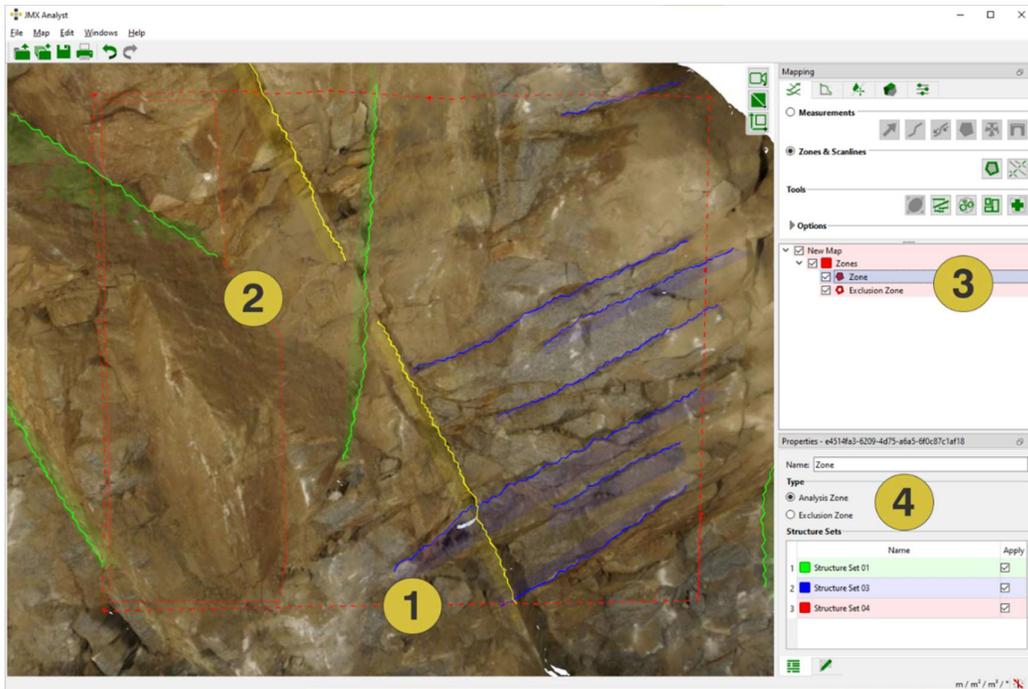
1 *Analysis Zone*

2 *Exclusion Zone*

3 *Zones* listed in the *Structure* tab

4 Selection of *Zone* type in the *Properties* pane

Figure 27: Analysis Zone (red dashed line) and Exclusion Zone (red dotted line) for Trace Map Analysis
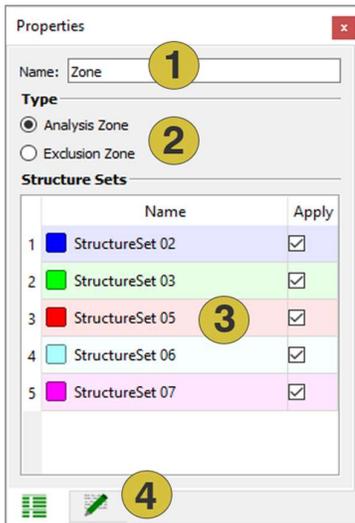
1 Name of the *Zone* (editable)

2 Type of *Zone* (editable)

3 Selection of *Structure Set* (editable)

4 Notes (editable)

Figure 28: Properties pane of Zones

Context menu:

- *Edit*

  Insert a point by holding "*Ctrl*" and clicking the right mouse button. Open the *Zone by* holding "*Alt*" and clicking the right mouse button. Move a point by holding "*Shift*" and clicking the right mouse button.

- *Set Colour*

  Defines a new colour for the *Zone*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Zone* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Zone* in the 3D viewer

- *Delete*

  Deletes the selected *Zone*

- *Show Properties*

  Opens the *Properties* pane

4.10 Scanline

The *Scanline* is a *Structure Tool* directly related to geological data evaluation. It is a line along the surface defined by two points identifying the intersections with *Traces* and *Areas*, calculating the distances between the intersections and providing statistical data on the joint spacing along the *Scanline*. *Scanlines* appear as a blue dashed lines in the 3D viewer and are managed in an individual list (called *Scanlines*) in the *Structure* tab of the *Mapping* pane (Figure 29). If the *Scanline* entry is selected in the list intersection points between the *Scanline* and *Traces/Areas* are highlighted in the 3D viewer.

Standard operating procedure:

1. Activate "*Zones & Scanlines*" in the toolbar of the *Structure* tab by clicking the corresponding radio button ⊙ Zones & Scanlines

2. Click on the *"Scanline"* ⋇ icon in the toolbar or use the shortcut key "*S*"

3. Mark the start point of the *Scanline* with a left button mouse click

4. Mark the end point of the *Scanline* with a left button mouse click

5. Finish the *Scanline* and add continue the mapping by pressing the "*Space*" key **or** finish the *Scanline* by clicking "*Enter*" or by clicking the "*Scanline*" ⋇ icon. The *Scanline* is displayed instantly in the corresponding list in the *Structure* tab.

Edit the *Scanline* measurement by a double click with the right mouse button on the item and set a new start and/or end position of the *Scanline* measurement by clicking the left mouse button. The point closer to the mouse cursor is affected.

Traces and *Areas* are used to calculate the spacing values for *Set Spacing, Normal Set Spacing,* and *Total Spacing*. The *Scanline* determines all intersection points between *Traces* and *Areas*. The relevant intersection point of a *Scanline* and a particular structure is determined according to the relative orientation of the structure to the *Scanline* (Figure 30). Spacing values are based on the distances between intersection points. If the structure's spaceside normal vector (e.g. N_1) (the normal vector which points towards the free space) points in the same direction as the scanline vector **S**, the first intersection point is chosen. If the structure's spaceside normal vector (e.g. N_2) points in the opposite direction as the scanline vector **S**, the last intersection point is chosen.
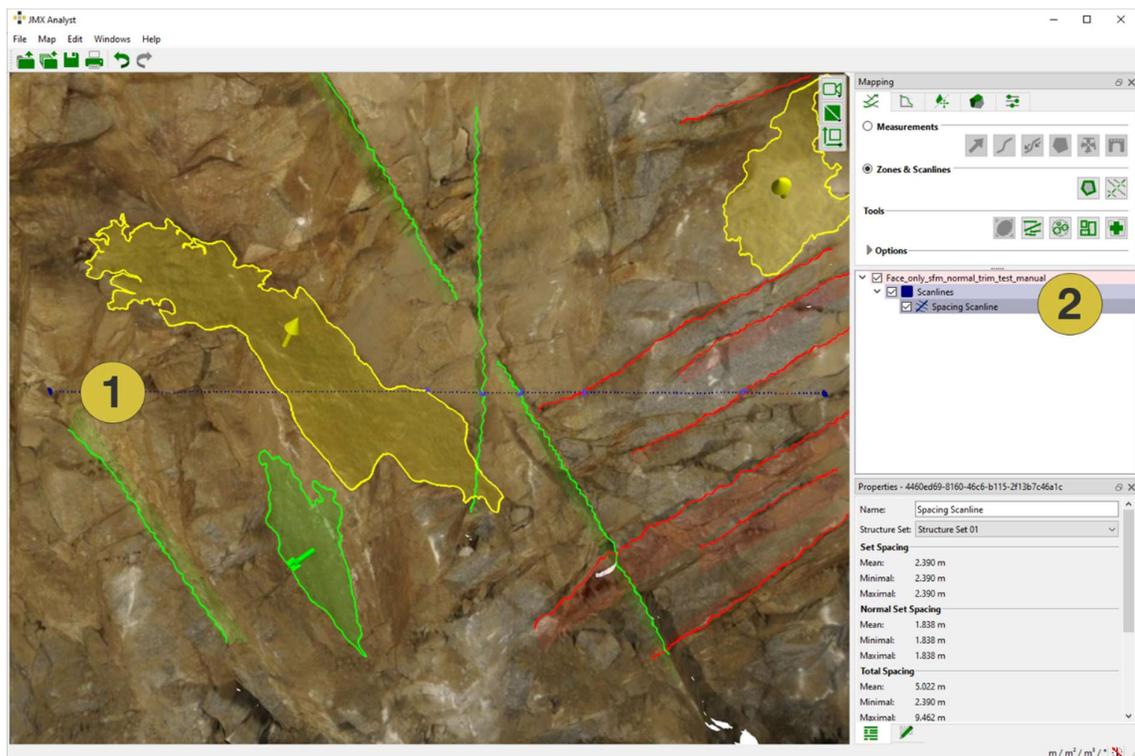
1　*Scanline*
2　*Scanline* listed in the *Structure* tab

Figure 29: Scanline (blue dashed line) for calculating the spacing between Traces and Areas in arbitrary directions. Intersection points are marked with blue dots.
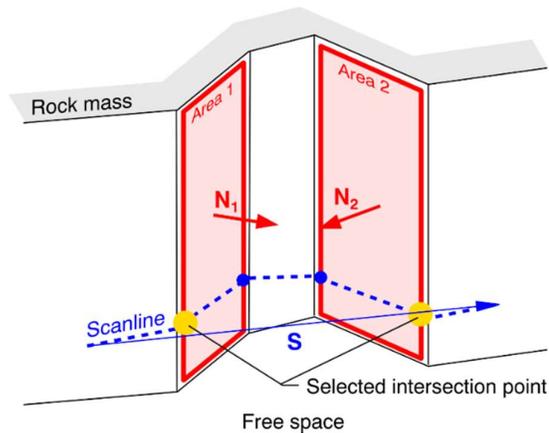
Figure 30: Principle of the Scanline tool

Figure 31 shows the *Properties* pane of *Scanlines*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Scanline*. The name is editable in order to provide a descriptive name. Spacing statistics can be displayed from the entire *Map* or from individual *Structure Set (*selected in the pull down menu). Independent of the selection the dialog reveals spacing parameters obtained from individual *Structure Sets* (*Set Spacing*, *Normal Set Spacing*) and from the entire *Map* (*Total Spacing*). In addition the trend and plunge of the vector (defined as the vector between start and end point) of the *Scanline* is given and the number of intersections (in the selected *Structure Set* and overall *Map*). The *Scanline Intersection* dialog (Figure 32) is opened by clicking "*Show Intersections*" [Show Intersections] button in the *Properties* pane. The dialog is also available via the context menu. It reveals intersection point co-ordinates. If an intersection point is selected in the *Scanline Intersection* dialog, the corresponding point on the 3D model is highlighted as a yellow sphere (see Figure 33). Scanline data is exported to ".csv" by clicking the "*Export*" [Export] button. Customized notes can be added to individual *Scanlines* in the *Notes* 🖉 tab.
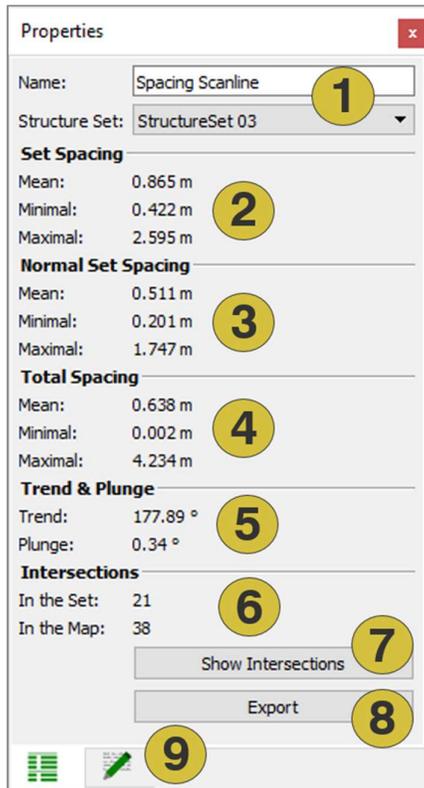
1   Name of the *Scanline* and *Structure Set* (editable)

2   Set spacing

3   Normal set spacing

4   Total spacing (entire *Map*)

5   Trend and plunge of the *Scanline*

6   Intersections in set and in *Map*

7   Show intersection points

8   Export spacing data

9   Notes (editable)

Figure 31: Properties pane for Scanlines

1 Identification of the *Scanline* intersection point (IPID)

2 Measurement identification (MID)

3 Intersection point co-ordinates (x,y,z or E, N, H)

Figure 32: Scanline Intersection dialog including number of intersections, table of intersection and position (left). Highlighted intersection point in the dialog and in the 3D viewer.
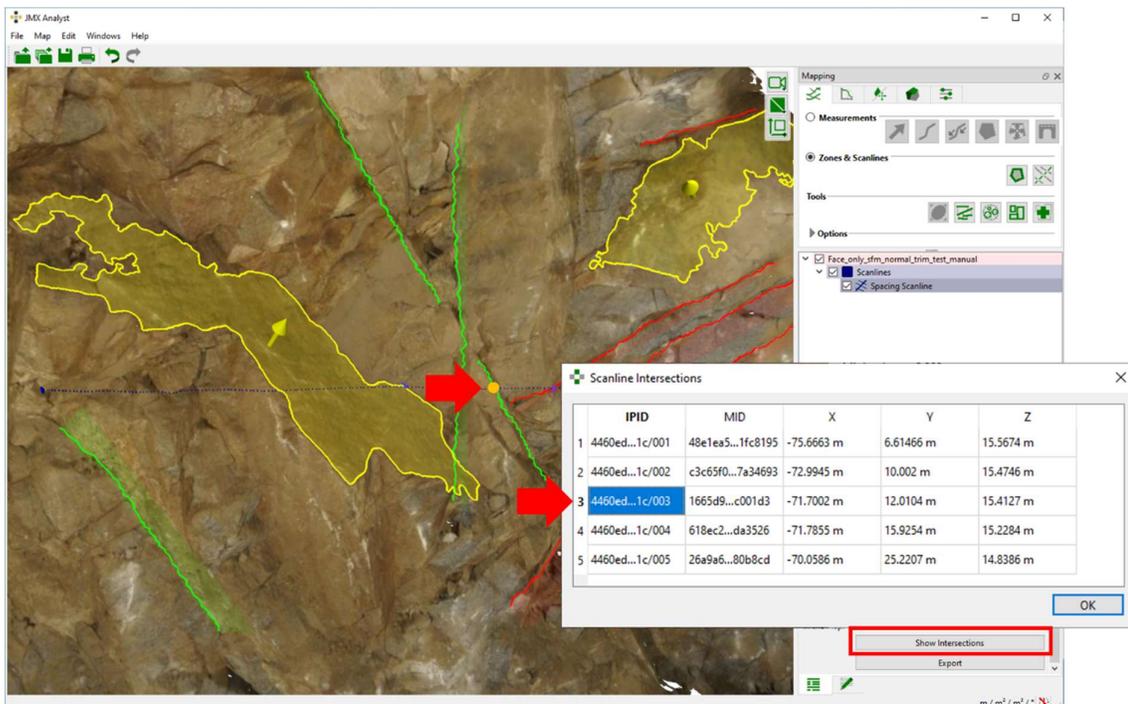
Figure 33: Scanline annotation in the 3D viewer. The Scanline is a blue dashed line. If it is selected, intersection points are highlighted as blue markers. Note the highlighted intersection point (yellow sphere).

Context menu:

- *Edit*

  Moves one of the end points of the *Scanline* to a new position defined by a click with the left mouse button. The point closer to the mouse cursor is affected.

- *Show intersections*

  Opens the *Scanline Intersection* dialog

- *Active*

  Activates (shows) and deactivates (hides) the selected item.

- *Look at*

  Centers the *Scanline* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Scanline* in the 3D viewer

- *3D View-dependent Redraw*

  Redraws the *Scanline* in subject to the current view

- *Delete*

  Deletes the selected *Scanline*

- *Show Properties*

  Opens the *Properties* pane for the *Scanline*

- *Export*

  - *Export Scanline Data as CSV*   Exports the *Scanline* as ".csv" file

  - *Export as DXF*   Exports the *Scanline* as ".dxf" file

  - *Export as VRML*   Exports the *Scanline* as ".vrml" file

4.11 Discontinuity Model

Discontinuities are used to model the extent of a fracture. A *Discontinuity Model* in *Analyst* is a finite subset of a plane bounded by a defined planar curve, the bounding curve (Figure 34). The plane of a *Discontinuity Model* is defined by a position (three co-ordinates) and orientation (normal vector, or dip direction and dip angle, and an in-plane angle depending on the discontinuity shape). These parameters are taken from a *Trace*, *Area* (each of which having an orientation) or a single *Orientation* measurement. The user chooses the shape, orientation and position of the bounding curve. The software proposes a bounding curve after generation which aims to approximate the corresponding *Area* or *Trace*. In case of generating a *Discontinuity Model* based on a single *Orientation*, standard values for the discontinuity size are chosen (radius 1 m, A 2 m, B 1 m, Epsilon 0°).

Standard operating procedure:

1. Select one *Orientation, Trace* or *Area* from the *Structure List* or the 3D model using the left mouse button

2. Click on the "*Add Discontinuity Model*" icon or use the shortcut key "*D*". The feature is also available in the context menu of the individual measurements. The orientation of the *Discontinuity Model* is displayed instantly in the *Structure List* (see Figure 34).

3. Adjust the settings of the *Discontinuity Model* in the *Properties* pane (see Figure 35).

Edit the *Discontinuity Model* by a double click with the right mouse button on the item:

- Set a new positon by clicking the left mouse button

- *Move Discontinuity Model on Plane* by holding "*Shift*" and clicking the right mouse button

- Shift the *Discontinuity Model* by holding "*Shift*" and turning the mouse wheel

Discontinuity Models can only be moved if they are unlocked.

Hint:

Discontinuity Models can only be assigned to a *Trace* or *Area* if they have also an *Orientation*.

Hint:

The orientations of *Discontinuity Models* are **not** considered in stereographic projections and statistical data given in *Analyst*. They are also *not* considered in spacing calculations.

Hint:

By default, *Discontinuity Models* have the same colour as the corresponding *Annotation Element.* Recolouring of *Discontinuity Models* is performed in the context menu by a click on "*Set Colour*".

Figure 35 shows the *Properties* pane for *Discontinuity Models*. The pane is activated in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Discontinuity Model*, information to which *Structure Set* the *Discontinuity Model* belongs and the "*Unlock*" and "*Reset*" button. In addition, the orientation, the shape, the size and other shape parameters of the modelled discontinuity is given. The name and the shape parameter(s) can be edited in any case. The in-plane angle Epsilon can only be edited for rectangles and ellipses. The orientation can only be edited if the *Discontinuity Model* is unlocked.
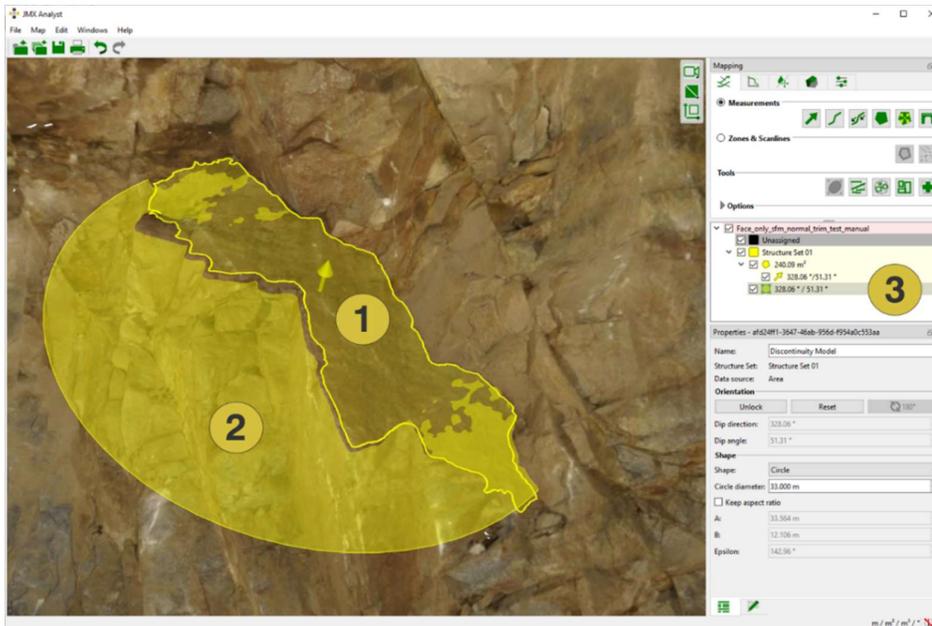
1   *Area*

2   *Discontinuity Model* based on the *Area*

3   *Discontinuity Model and Area* in the *Structure List*

Figure 34: Discontinuity generated from an Area
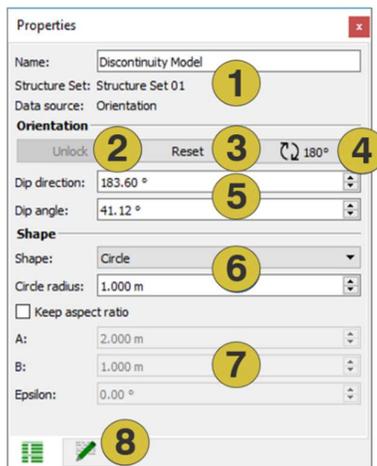
1   Name of the *Discontinuity Model* (editable), Structure Set and data source

2   Unlocks the *Discontinuity Model* from the *Structure Measurement*

3   Retrieves original settings

4   Rotate *Discontinuity Model*

5   Orientation of the *Discontinuity Model* (editable)

6   Selection of shape (editable)

7   Shape parameter (editable)

8   Notes (editable)

Figure 35: Properties pane for Discontinuity Models

Note:

Discontinuity Models can be exported as ".dxf" and ".csv" and ".vrml" files. See Chapter 9.2 for further information.

Editing Discontinuity Models

Discontinuity Models can be edited if they are selected with a click with the left mouse button on the entry in the *Structure List* or on the display in the 3D viewer. Selected *Discontinuities* are highlighted in the *Structure List* with a shaded background and with the boundary curve in the 3D viewer. Editing of *Discontinuity Models* is performed in the *Properties* pane (see Figure 35).

Changing the shape

Three shapes i.e. circle, ellipse and rectangle are available (see Figure 36). The shape changes by clicking the pull down menu "*Shape*" in the *Properties* pane (Figure 35). When changing the shape also different fields of shape parameter become active. The shape can be changed for locked and unlocked *Discontinuity Models*.
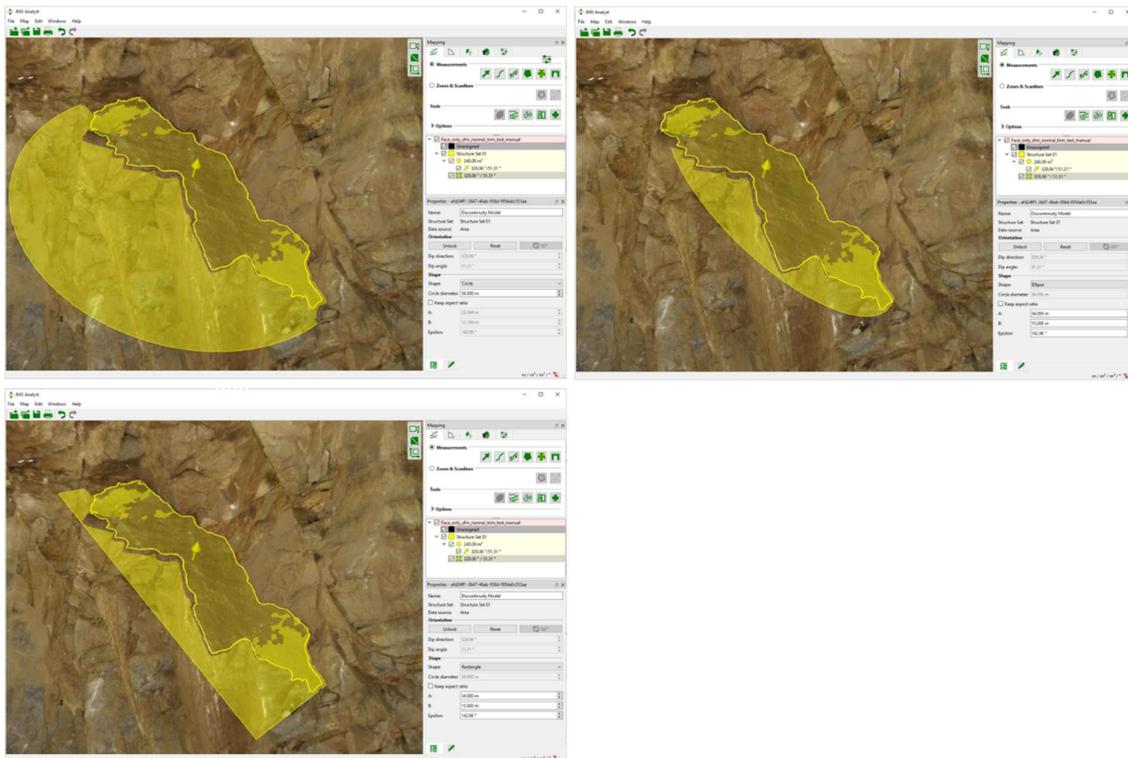
Figure 36: Changing the shape of the Discontinuity Model by choosing circle (top left), ellipse (top right) or rectangle (bottom left) in the pull-down menu

Changing the size

The size of a *Discontinuity Model* is defined by:

- Circle: the radius of the circle

- Ellipse and rectangle: the longest dimension (A) and the shortest dimension (B)

After modelling the discontinuity the software proposes the size parameters to approximate the original *Trace* or *Area*. For editing the size the desired values can be entered in the active fields (radius or A, B; see Figure 37 to Figure 39) or by using the scrolling mechanism (see Chapter 3.5). The ratio between the values A and B can be kept constant by ticking the box "*Keep aspect ratio*" for ellipses and rectangles (Figure 38). If the box "*Keep aspect ratio*" is not selected, the values A and B are changed independently (Figure 39). The size of the *Discontinuity Model* can be changed if it is locked and unlocked.
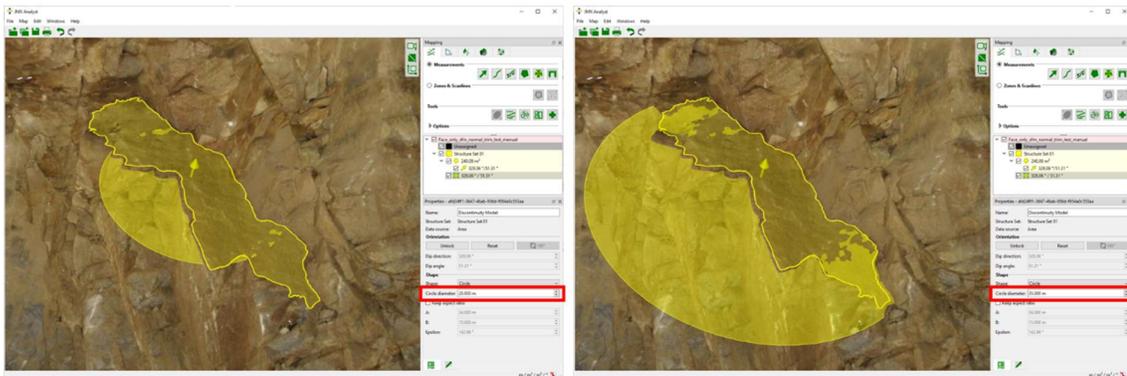
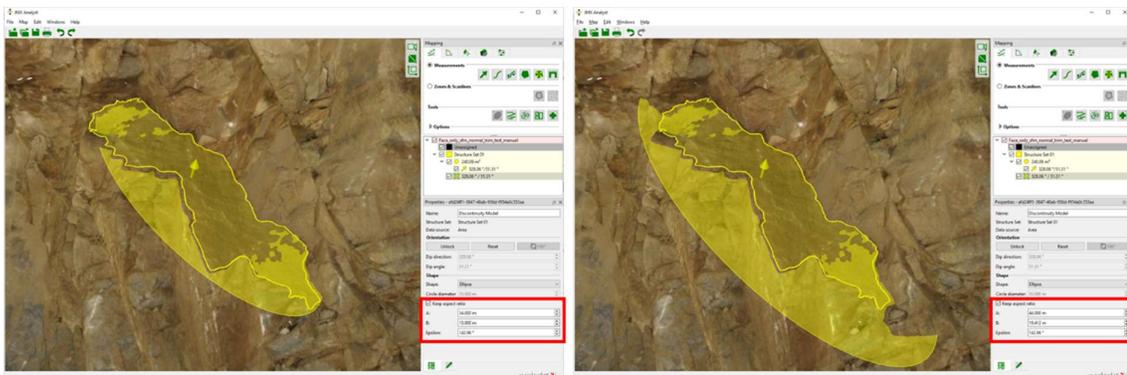*Figure 37: Changing the size of the circle by entering the radius*

Figure 38: Changing the size of the ellipse with "Keep aspect ratio" activated
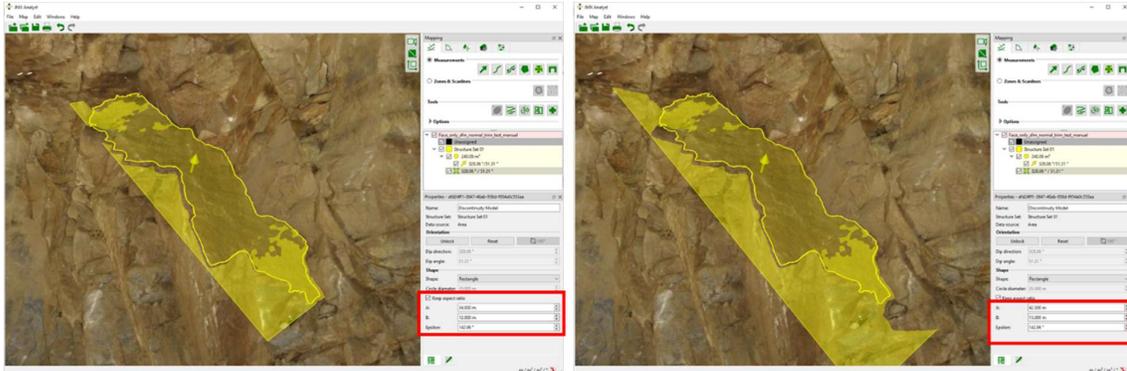
Figure 39: Changing the size of a rectangle without "Keep aspect ratio" activated

Changing the orientation in the plane (epsilon)

The orientation in the plane is the angle (epsilon) of the *Discontinuity Model* relative to the dip line. It is only relevant for ellipses and rectangles. Epsilon is measured in clockwise direction when looking towards the upward normal vector of the plane (Figure 40). If epsilon is zero, the longest dimension of the ellipse or rectangle corresponds to the dip line of the plane. For editing the angle epsilon the desired values can be entered in the active field (epsilon, see Figure 41) or by using the scrolling mechanism (see Chapter 3.5).
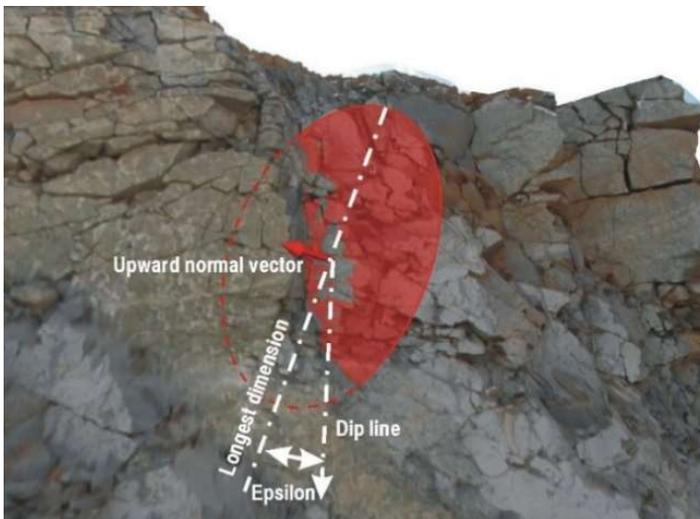

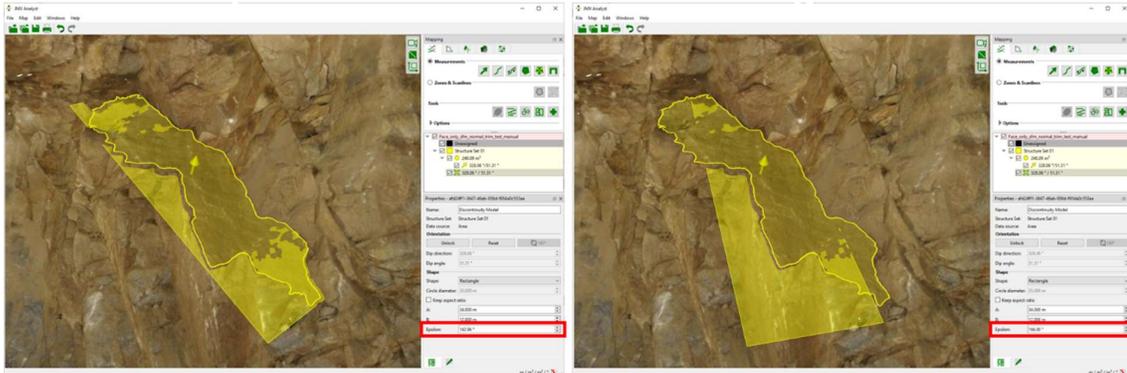*Figure 40: Definition of angle epsilon for the orientation in the plane*

Figure 41: Changing the orientation in the plane by changing the angle epsilon

Unlocking and resetting a Discontinuity Model

Discontinuity Models can be locked or unlocked. They are unlocked by clicking the *"Unlock"* button in the *Properties* pane. The locked status can be recovered by clicking on the "*Reset*" button in the *Properties* pane. Unlocking a *Discontinuity Model* gives the user more degrees of freedom for editing. Unlocking enables to move the discontinuity to another position and changing the orientation (dip direction and dip angle). A locked *Discontinuity Model* indicates the user that there were no essential changes to the plane data compared to the original *Area* or *Trace* measurement. The icon of a locked *Discontinuity Model* in the *Structure List* appears with holders . Unlocked *Discontinuity Models* indicates the user that there might have been essential changes compared to the original *Area* or *Trace* measurement. The icon of an unlocked *Discontinuity Model* in the *Structure List* appears without holders .

Changing the position of a Discontinuity Model

The position of a *Discontinuity Model* can only be changed if it is unlocked. The position is changed by moving the *Discontinuity Model* in the 3D viewer in the *Edit* mode while keeping the left mouse button pressed. Two modes are available:

- *Move Discontinuity Model*
  The *Discontinuity Model* can be placed arbitrarily on the 3D model by clicking the right mouse button (Figure 42)

- *Move Discontinuity Model on Plane*
  The *Discontinuity Model* can only be moved inside the original plane but on an arbitrary position by holding "*Shift*" and clicking the right mouse button (Figure 43)
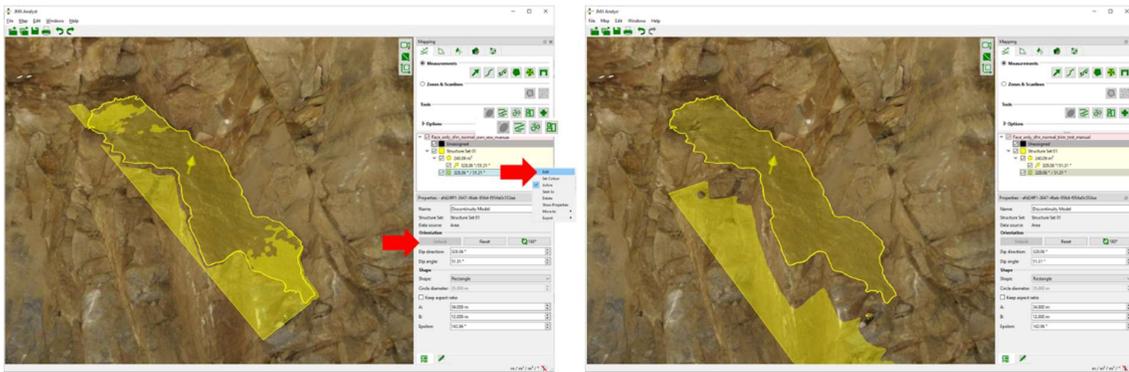
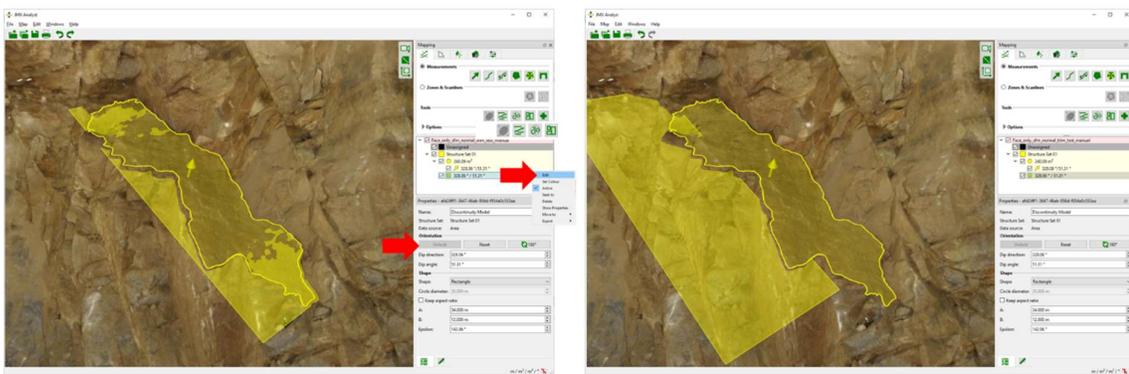*Figure 42: Moving a Discontinuity Model to a new arbitrary position on the 3D model in the 3D viewer*

Figure 43: Moving a Discontinuity Model to a new position on the original plane in the 3D viewer

Changing the orientation of a Discontinuity Model

The orientation (dip direction and dip angle) can only be changed for an unlocked *Discontinuity Model*. Dip direction and dip angle can be edited (Figure 44) in the *Properties* pane by entering the desired values or by using the scrolling mechanism (see Chapter 3.5).
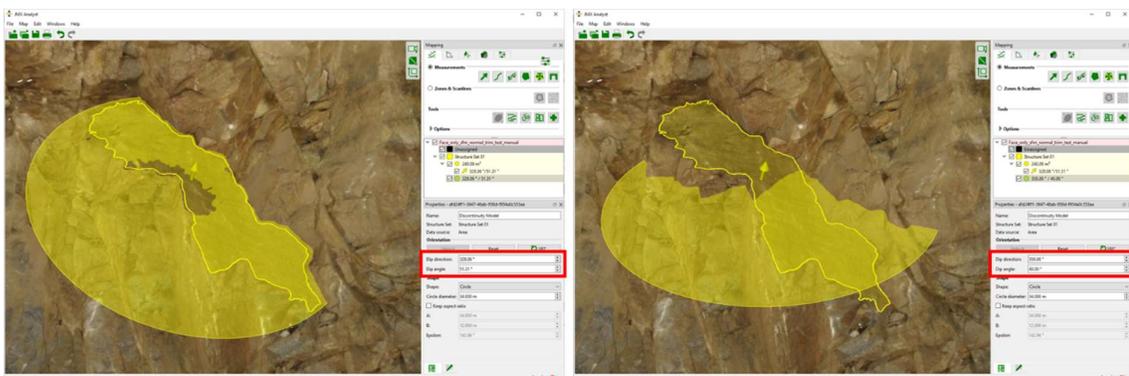

Figure 44: Changing the orientation (dip direction and dip angle) of a discontinuity

Rotate Discontinuity by 180°

Rotation by 180° can only be performed for an unlocked *Discontinuity Model* by clicking on the according button in the *Properties* pane (Figure 45).
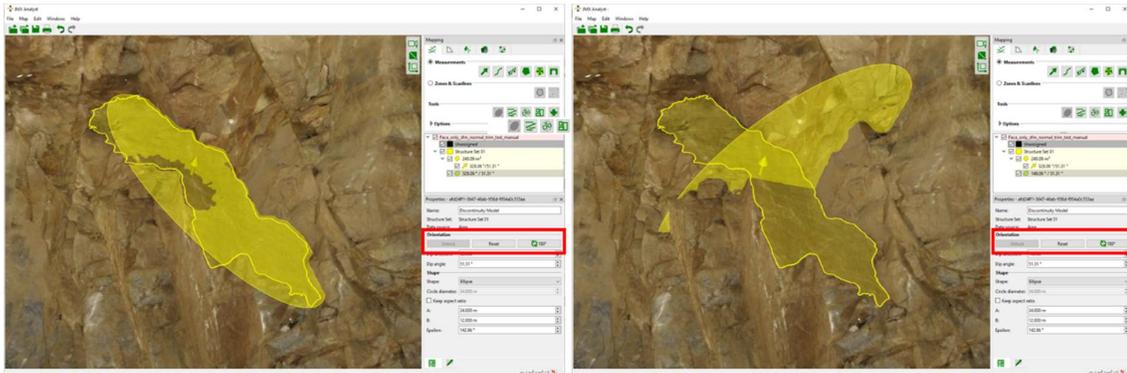

Figure 45: Rotation of a Discontinuity Model

Context menu:

- *Edit*
  Set a new positon by clicking the left mouse button. *Move Discontinuity Model on Plane* by holding "*Shift*" and clicking the right mouse button. Shift the *Discontinuity Model by holding* "*Shift*" and turning the mouse wheel. *Discontinuity Models* can only be moved if they are unlocked.

- *Set Colour*
  Allows changing the colour of a *Discontinuity Model*

- *Look at*
  Centers the *Discontinuity Model* in the 3D viewer

- *Look at and Zoom*
  Centers and zoom the *Discontinuity Model* in the 3D viewer

- *Delete*
  Deletes the selected *Discontinuity Model*

- *Show Properties*
  Opens the *Properties* pane for the *Discontinuity Model*

- *Move to*
  Moves the *Discontinuity Model* to another *Structure Set*

- *Export* (see Chapter 9.2 for further information)

  - *Exports Discontinuity Model as DXF*   Exports the *Discontinuity Model* as ".dxf" mesh

  - *Exports Discontinuity Model as CSV*   Exports the *Discontinuity Model* as ".csv"

o	*Export as DXF*	Exports the *Discontinuity Model* as ".dxf"
o	*Export as VRML*	Exports the *Discontinuity Model* as ".vrml

4.12 Discontinuity Surface

Discontinuity Surface is used to model the direction and extension of fractures, wavy discontinuities and faults. *Discontinuity Surfaces* can be assigned to *Trace* measurements. The modelled surface is defined by trend and plunge whereas the parameters are derived from the orientation of the initial *Trace* measurement. If the originating *Trace* has not enough variation on depth no orientation in provided and the direction of the *Discontinuity Surface* is obtained derived from the current view (see Chapter 4.4). After first generation, *Discontinuity Surfaces* can be adjusted individually by the user in terms of trend, plunge and extension.

Hint:

By default, *Discontinuity Surfaces,* have the same colour as the corresponding *Trace.* Recolouring of *Discontinuity Models* is performed in the context menu by a click on "*Set Colour*".

Standard operating procedure:

1. Select *Trace* from the *Structure List* or the 3D model using the left mouse button

2. Click on the "*Add Discontinuity Surface"* icon or use the shortcut key "S". The feature is also available in the context menu of the individual measurements. The trend, plunge and extension of the *Discontinuity Surface* is displayed instantly in the *Structure List* (see Figure 46).

3. Adjust the settings of the *Discontinuity Surface* in the *Properties* pane (see Figure 47).

Figure 47 *shows* the *Properties* pane for *Discontinuity Surfaces*. The pane is activated in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Discontinuity Surface*, information to which *Structure Set* the *Discontinuity Surface* belongs and the "*Reset*" and "*Project from View"* button. In addition, the orientation (trend and plunge) and the extension modelled surface is given. The name, orientation and extension parameter(s) can be edited.
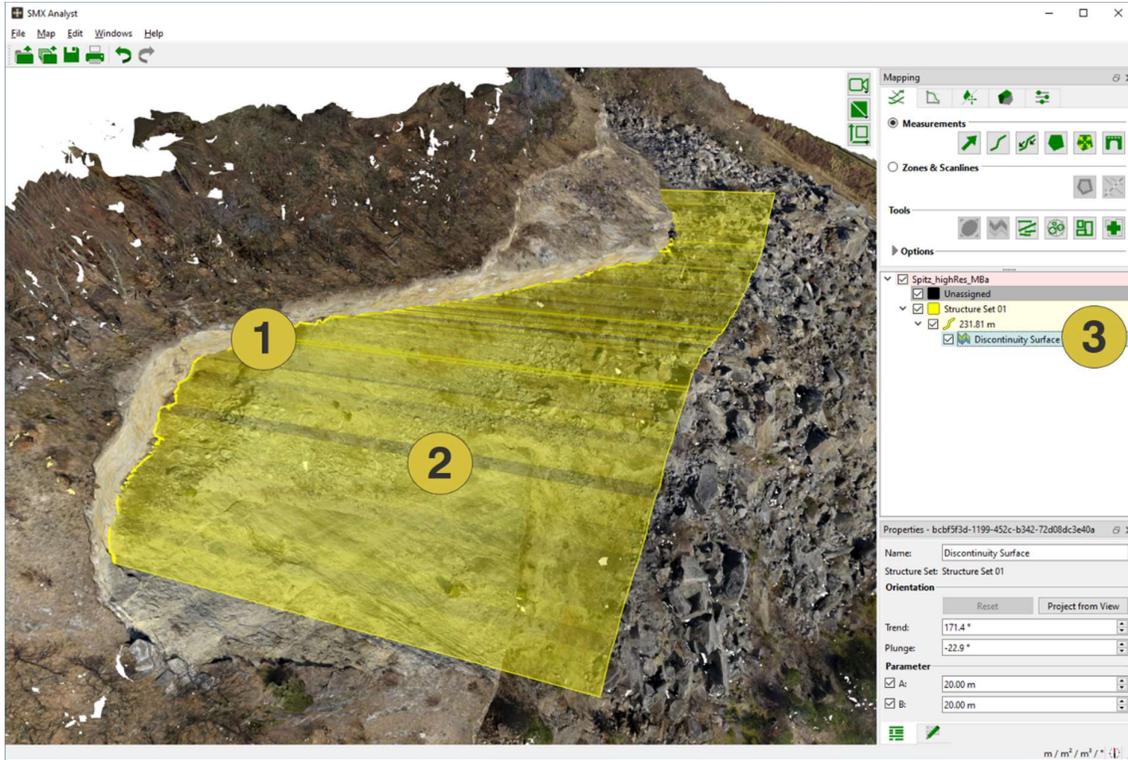
1 *Trace*

2 *Discontinuity Surface* based on the *Trace*

3 *Discontinuity Surface* in the *Structure List*

Figure 46: Discontinuity Surface generated from a Trace measurement
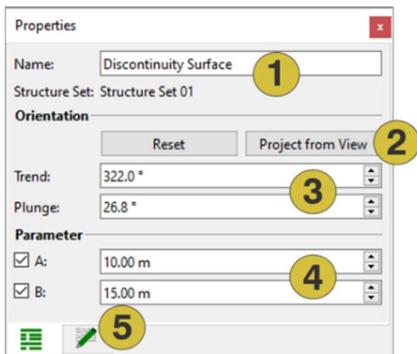
1 Name of the *Discontinuity Surface* (editable), Structure Set and data source

2 Retrieves original settings / Modifies orientation in respect to the current view

3 Adjustment of trend and plunge (editable)

4 Adjustment of extension (editable)

5 Notes (editable)

Figure 47: Properties pane of Discontinuity Surfaces

Discontinuity Surfaces can be edited if they are selected with a click with the left mouse button on the entry in the *Structure List* or on the display in the 3D viewer. Selected *Surfaces* are highlighted in the *Structure List* with a shaded background and with the boundary curve in the 3D viewer. Editing of *Discontinuity Models* is performed in the *Properties* pane (see Figure 47).

Changing the orientation of a *Discontinuity Surface* is possible in two modes (Figure 48):

- *Trend/Plunge*

  The orientation of a *Discontinuity Surface* can be adjusted by trend and plunge by entering new the desired values in the corresponding fields

- *Project from View*

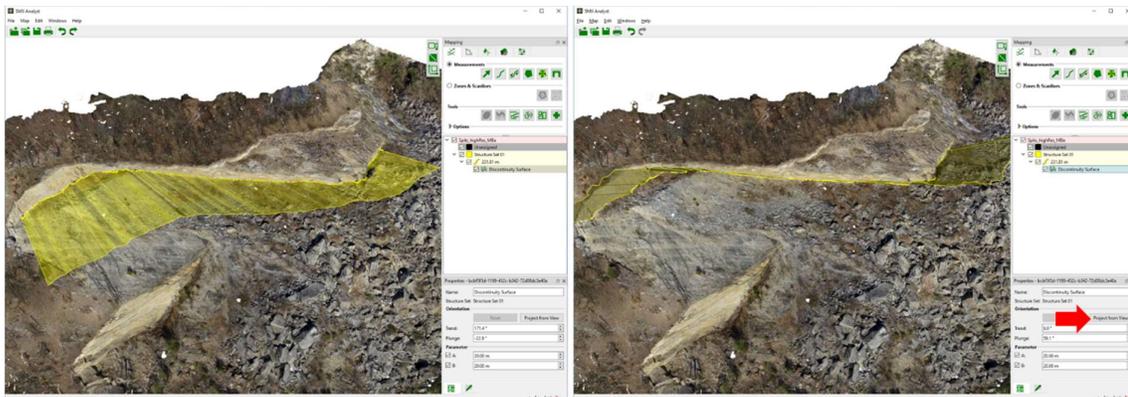 The surface is projected from the current view in the 3D viewer

Figure 48: Changing the orientation of a Discontinuity Surface in respect to the current view.

The extension of *Discontinuity Surfaces* can be modelled by changing the A parameter (in direction of the orientation) and B parameter (180° against the orientation) in the properties pane (see Figure 49).

Hint:

If a *Discontinuity Surfaces* should follow exactly the surface gradient (mesh) the modelling of the surface should be reduced to one direction by deactivation the checkbox in front of the A or B parameter.
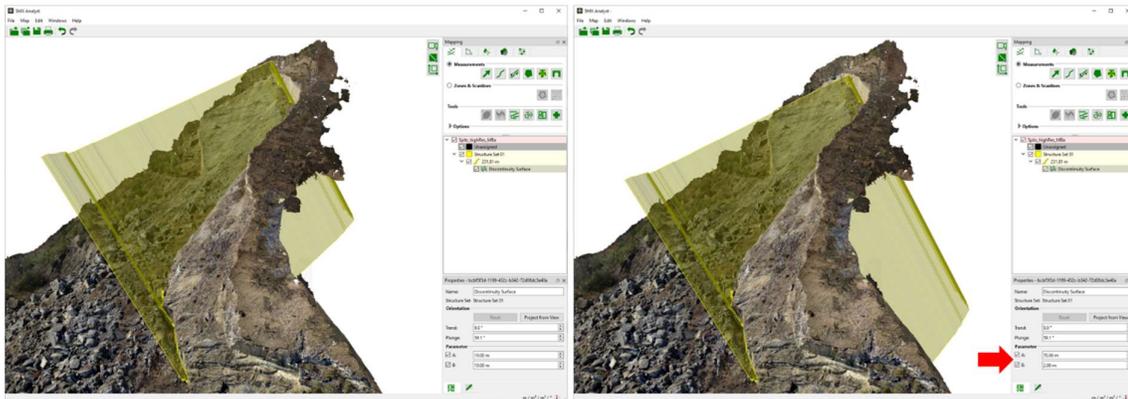
Figure 49: Changing the extension of a Discontinuity Surface by adaptation of the parameter A and B

Context menu:

- *Project from View*
  Projects the direction of the surface in respect current view in the 3D viewer

- *Reset*
  Resets the orientation to the originating value

- *Set Colour*
  Allows changing the colour of a *Discontinuity Surface*

- *Active*

- *Look at*
  Centers the *Discontinuity Model Surface* in the 3D viewer

- *Look at and Zoom*
  Centers and zoom the *Discontinuity Surface* in the 3D viewer

- *Delete*
  Deletes the selected *Discontinuity Surface*

- *Show Properties*
  Opens the *Properties* pane for the *Discontinuity Surface*

- *Export* (see Chapter 9.2 for further information)

  - *Exports Discontinuity Surface as DXF*   Exports the *Discontinuity Surface* as ".dxf" mesh

4.13 Trace Map Analysis

Trace Map Analysis in the *Analyst* shows data on trace spacing. This *Structure Tool* is controlled via the *Trace Map Analysis* dialog. The input data is defined by the entire *Map* or if defined *Analysis Zones and Exclusions Zones* (see Chapter 4.9)*.* Considered *Annotation Elements* for analysis are *Trace*s, *Areas* and *Bridges*. Results are displayed in a distribution plot (histogram).

Upon calling the *Trace Map Analysis* dialog, the *Projection Plane* of the *Structure Set / Analysis Zone* is displayed in the 3D viewer together with the bounding box enclosing the selected measurements (Figure 50 and Figure 51). Projected *Traces* appear as non-parallel straight lines in the colour of the *Structure Set*. Scanlines are outlined as dotted lines whereas the intersection points are indicated by a circle.

Standard operating procedure:

1. Click on the *"Trace Map Analysis"* ⊯ icon in the toolbar of the *Structure* tab of the *Mapping* pane or chose "*Window | Trace Map Analysis*" in the menu bar.

2. The *Trace Map Analysis* dialog appears (Figure 50) revealing the analysed data

Note:

The *Trace Map Analysis* dialog is a non-modal dialog. This means work on the main window can continue while the dialog window has been left open. Any changes from the main window will update the projection immediately.

Figure 50 shows a projected trace map of an entire *Map*. It is possible to switch between the *Structure Sets* by using the pull down menu. If *Analysis Zones* are defined it is possible to switch between individual zones by using the pull down menu

Spacing calculations consider *Traces* and *Areas* which are projected with their orientation onto a reference plane, i.e. *Projection Plane*, parallel to the mean orientation vector of the *Structure Set*. If a *Trace* has no orientation, the mean orientation of the *Structure Set* is used for the projection. The direction of the scanlines is parallel to the mean orientation of the *Structure Set*. The calculation of the *Trace* and *Bridge* lengths is based on the length along the surface.

Single *Traces* can be selected in the *Trace Map Analysis* dialog by clicking with the left mouse button on the item. It is then highlighted in the projection, the *Structure List* and in the 3D viewer. Using the "*Seek to"* function from the context menu of the annotation, the item found on the 3D model. Multiple selection is performed by holding "*Ctrl*" and clicking the left mouse button on the desired items. The middle mouse button is used to pan plot. The same can be done by pressing "*Ctrl*" **or** "*Shift*" and using the left mouse button. Zooming is performed by using the wheel if the computer mouse.

Note:

By using the check boxes "*Draw spacing*" and *"Draw intersection marks"* in the *Trace Map* configuration dialog the scanlines (dotted lines) and the intersections points (circles) are turned on and off (Figure 52).

1 Projected trace map
2 Distributions plots (available for *Spacing*, *Trace Length* and *Bridge Length*)
3 Pull down menu for switching between *Structure Sets* and *Analysis Zones*
4 Spacing and trace length statistics
5 *Configuration* tabs – Plot configuration and histogram configuration
6 Parameters of spacing and trace length statistics
7 Print trace map and statistics
8 Export spacing and trace length data

Figure 50: Trace Map Analysis dialog

Hint:

A context menu opens for selected *Trace* and *Bridge* measurements when clicking the right mouse button. It complies with the context menu of the selected measurement.
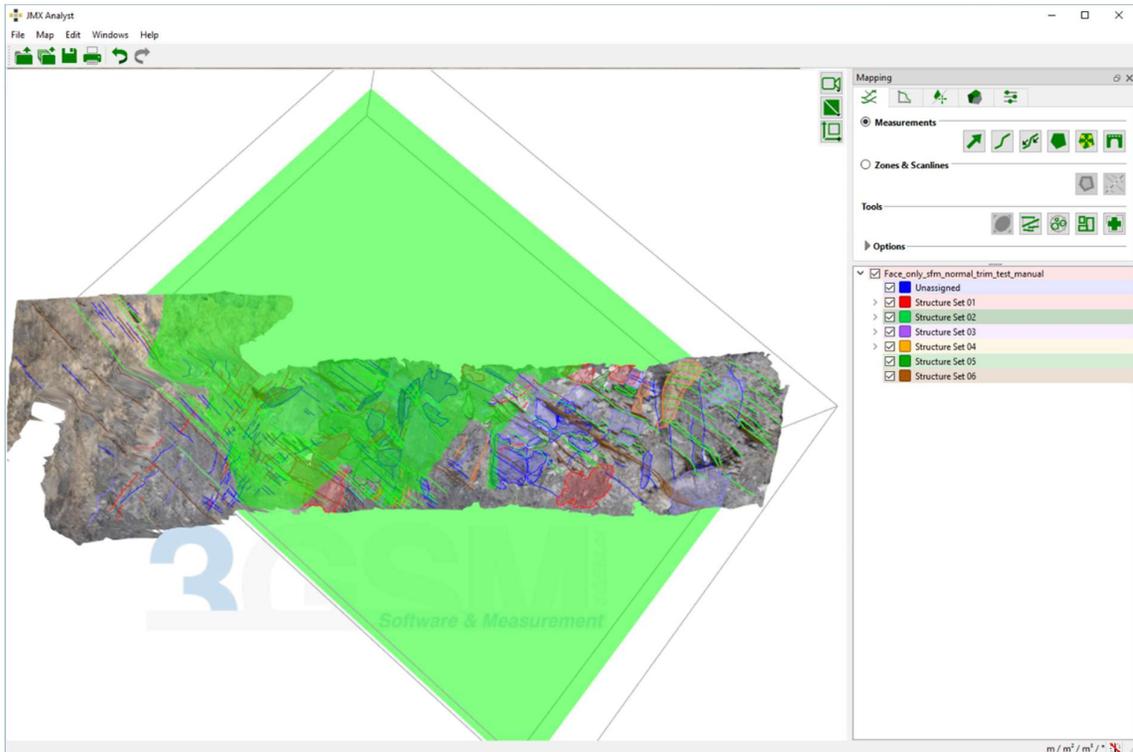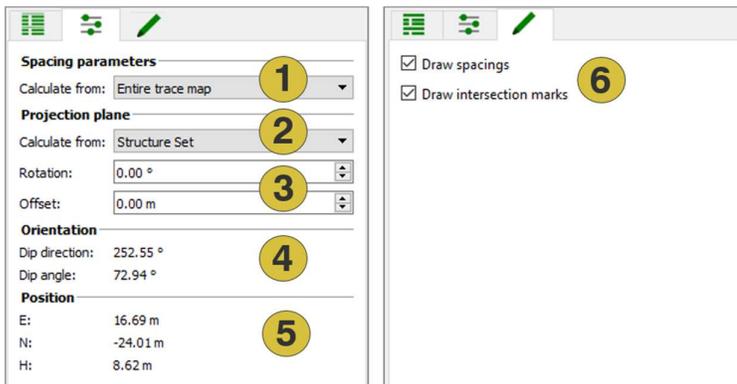
Figure 51: Projection Plane (green) and its bounding box in the 3D viewer

1   Configuration of spacing calculations

2   Configuration of calculating the *Projection Plane*

3   Rotation and Offset of the *Projection Plane*

4   Dip direction and angle of the *Projection Plane*

5   Position of the *Projection Plane*

6   Plot
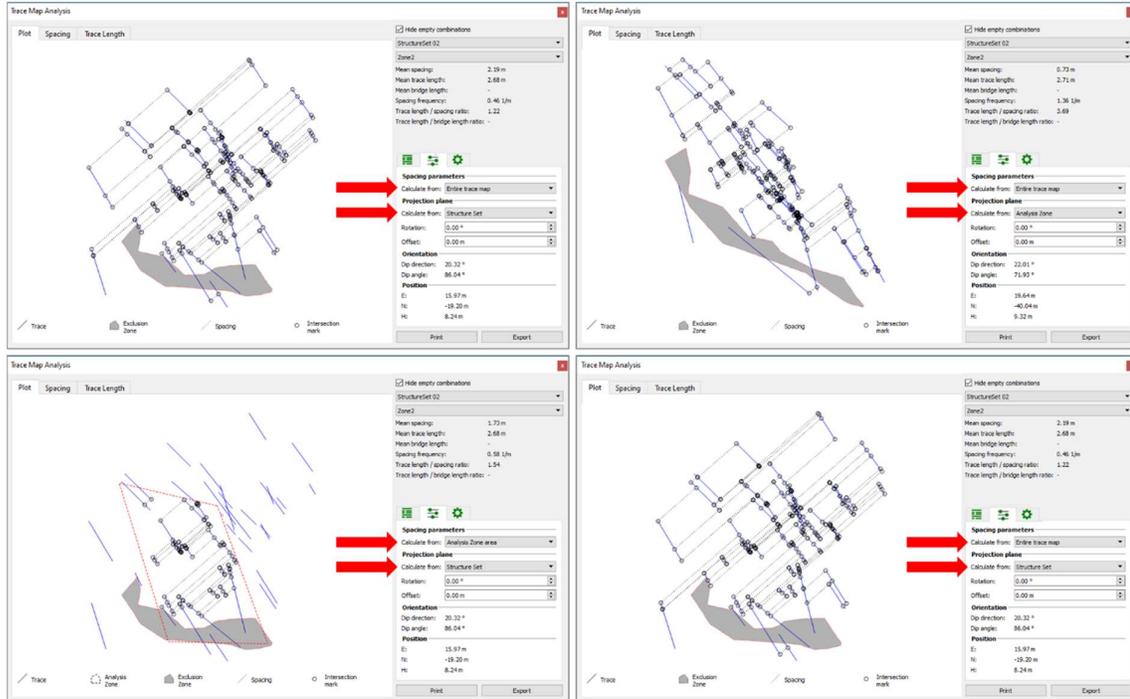
Figure 52: Trace map configuration

Figure 53: Trace map projection in dependence on the calculation configuration (red arrows) adjustable in the Configuration tab. Analysis zones are outlined by a red dotted line. Exclusions Zones are outlined by grey shaded area.

The statistics can be printed by clicking "*Print"* button and/or is written to a file in ".csv" format by clicking "*Export"* Export button in the *Trace Map Analysis* dialog. The ".csv" files can be imported by any spread sheets application like MS Excel. The structure of the ".csv" export data file is the following:

Header row: Structure Set Information
Structure Set, Selection, Dip direction (projection plane)[°], Dip angle of (projection plane)[°], E (projection plane)[m], N (projection plane)[m], H (projection plane)[m]

Header row: Statistics
Number of measurements, Frequency [1/m],Spacing measurements [m],Mean[m], Median [m], Standard deviation [m], Minimum [m], Maximum [m], Measurements [m]

Distribution plot

The distribution of *Spacing, Trace Length and Bridge Length* is visualized by plotting the cumulative relative length according to the total length. The individual plots are found in the corresponding *tabs* (see Figure 50). The representation of the distribution is shown in a histogram (Figure 54) that is configurable by the user in the *Histogram Configuration* tab. The number of bins as well as the scaling can be adapted (see Figure 55).

Figure 54: Spacing and Trace Length distribution plot

Figure 55: Histogram configuration

Context menu of the plot:

Show Grid	Shows/hides the grid
Show Tick Values	Shows/hides tick values
Show Axis Label	Shows/hides the axis labels
Save	Saves the current image as ".jpg" file

4.14 Stereonet Analysis

The *Stereonet Analysis* in the *Analyst* shows the poles of measured *Orientations* discriminated for each *Structure Set* in a hemispherical plot. In addition to the graphical representation, orientation statistics for each *Structure Set* (Figure 56) is given. *Orientation* measurements and statistics are displayed in the projection as poles and cones, respectively. Poles are drawn as dots in which the selected *Orientation* is highlighted. The cone of confidence is represented as a solid small circle. The spherical aperture is represented as a dashed small circle. The circle are displayed in the plot in the colour of the

corresponding *Structure Set*. The *Hemispherical Plot* shows only *Orientations* which are enabled in the *Structure List*.

Standard operating procedure:

1. Click on the *"Stereonet Analysis"* icon in the toolbar of the *Structure* tab of the *Mapping* pane or chose "*Window | Stereonet Analysis*" in the menu bar

2. The *Stereonet Analysis* dialog appears (Figure 50) showing the projection and the corresponding orientation statistic of each *Structure Set*

Note:

The *Stereonet Analysis* dialog is a non-modal dialog. This means work on the main window can continue while the dialog window has been left open. Any changes from the main window will update the projection immediately.

Two types of projections are available:

- *Lambert Projection* for equal area projection

- *Stereographic Projection* for equal angle projection

The projection type is selectable in the pull down menu in the *Stereonet Analysis* dialog (see Figure 56). By definition, the projections are displayed is the lower hemisphere (upper focal point).

Attention:

The *Stereonet Analysis* is always displayed with a north reference even if the 3D model is not geo-referenced. In this case the positive y-axis refers to the north direction.
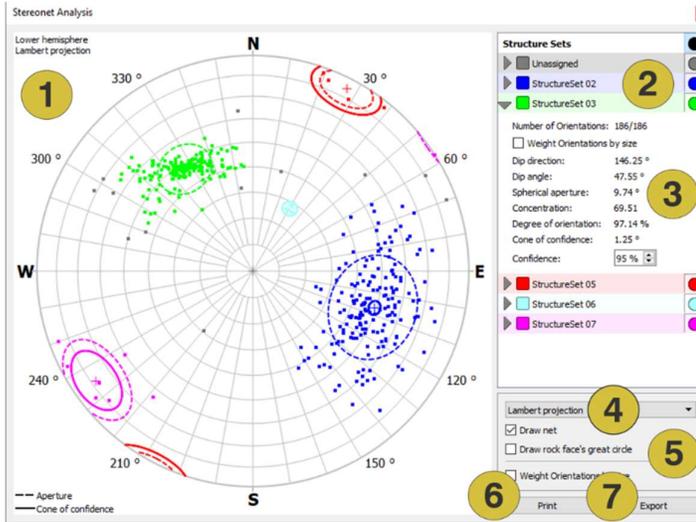
1 Projection of the lower hemisphere

2 Individual Structure Sets

3 Information and statistics to individual *Structure Sets*

4 Type of projection

5 Options

6 Print projection and statistics

7 Export projection and statistics

Figure 56: Stereonet Analysis of Orientations from individual Structure Sets

The *Structure Set* header allows configuring the display of the projection. The poles and statistics of an entire *Structure Set* can be turned off and off by clicking the radio button on right hand side of the header (Figure 57). The poles, the center of gravity, the circles for spherical aperture (dashed line) and cone of confidence (solid line) can be individually enabled and disabled by clicking with the right mouse button on radio button and ticking the corresponding checkboxes (Figure 58).
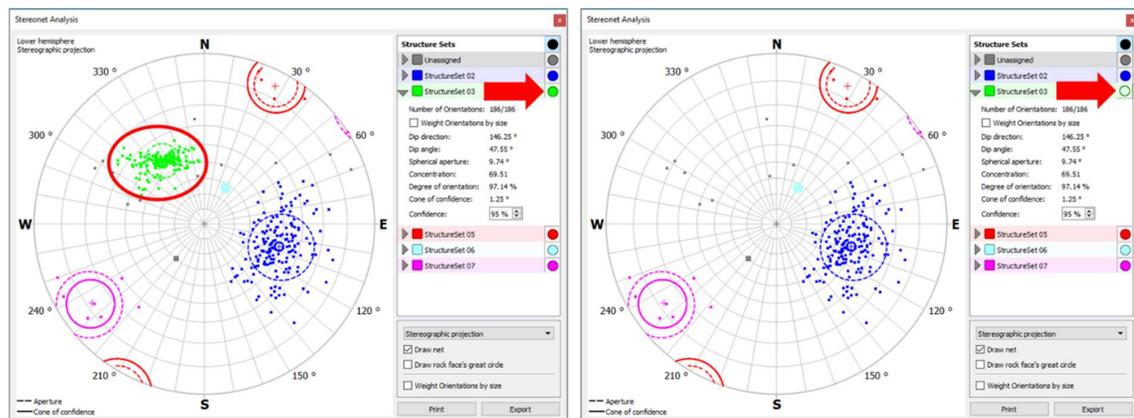

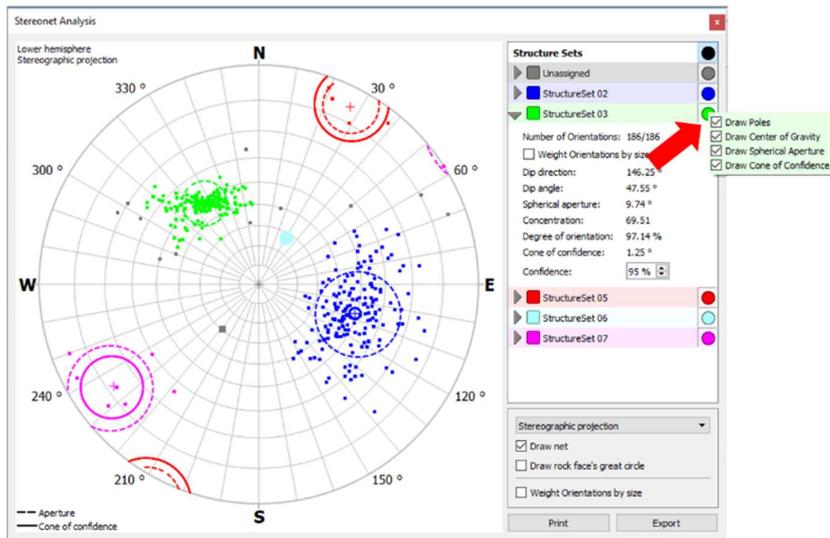*Figure 57: Enabling (red arrow) a Structure Set Stereonet Analysis*

Figure 58: Editing the projection of individual Structure Sets

The *Structure Set* header is followed by the *Orientation Statistics*. Following information and statistic is provided:

- *Number of Orientations:* Active number / Total number

- *Weight Orientations by Size* (3 in Figure 59)*:* The mean orientation vector of a *Structure Set* is the vector sum of all *Orientation* measurements contained in the *Structure Set* and divided by the number of measurements. This calculation assumes equal weights for each measurement and neglects the large joints may have more impact on the mean set orientation than small joints. *Analyst* allows to enable weights for each measurements. The weights are related to the maximum diameter of the structure. In consequence, large structures have more impact on the mean set orientation than small structures. The mean orientation vector of a *Structure Set* is then the sum of all weighted *Orientation* measurements contained in the *Structure Set*. *"Weight Orientations by size"* is enabled by ticking the corresponding checkbox.

Note:

Weight Orientations by Size is enabled for all *Structure Measurements* by ticking the checkbox in the general options of the *Stereonet Analysis* dialog (see 5 in Figure 59).

- *Dip direction*: mean value for a *Structure Set*

- *Dip angle*: mean value for a *Structure Set*

- *Spherical aperture*: spread of the *Orientations* around the mean value. It is comparable with the standard deviation for linear statistics

- *Concentration*: compares the *Orientation* sample size with the length of the mean orientation vector. The longer the vector for the same samples size the higher is the concentration. It describes the concentration of *Orientations* around a mean orientation value. Concentration = 0 describes a uniform distribution. Concentration equals Fisher's constant.

- *Degree of orientation*: normalised measure for the alignment of orientations. 0% means uniform distribution of *Orientations*, 100% means parallel alignment.

- *Cone of confidence*: defines a confidence region (small circle) around the calculated mean orientation which delimits the deviation of the true mean orientation for a certain level of confidence. If the confidence level is high, the cone of confidence is also large.

- *Confidence*: defines a level of certainty or probability, respectively, for the interpretation of results from statistical calculations. Higher levels of confidence include a wider spread compared to smaller levels. The confidence level can be edited in the dialog.

Note:

The check box "*Draw net*" in the *Stereonet Analysis* dialog turns the stereographic net on and off. The *Rock Face Great Circle* of the mean orientation of the whole 3D model can also be turned on and off using the check box "*Draw rock face's great circle*" (Figure 60).
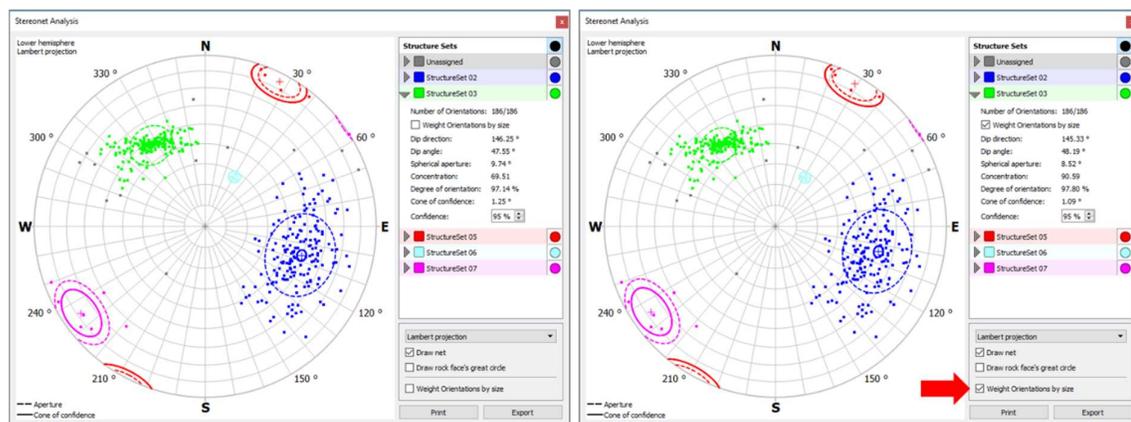

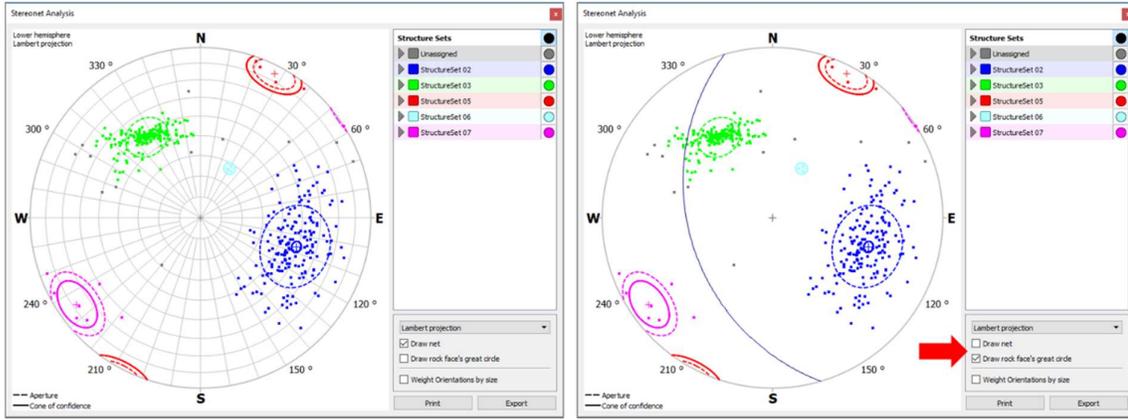*Figure 59: Hemispherical plot with orientations weighted by size disabled (left) and enabled (right)*

Figure 60: Hemispherical plot displayed with different configurations, i.e. "draw net" and "draw rock face´s great circle".

Single orientation poles can be selected in the hemispherical plot by clicking with the left mouse button on the pole. It is then highlighted in the plot, the *Structure List* and the 3D viewer (Figure 61). Using the "*Seek to*" function from the context menu of the annotation, the *Orientation* is found on the 3D model. Multiple selection of poles is performed by holding "*Ctrl*" and clicking the left mouse button on the desired items.

Hint:
A context menu opens for selected orientation poles when clicking the right mouse button. It complies with the context menu of the selected measurement (*Trace*, *Area*,...)
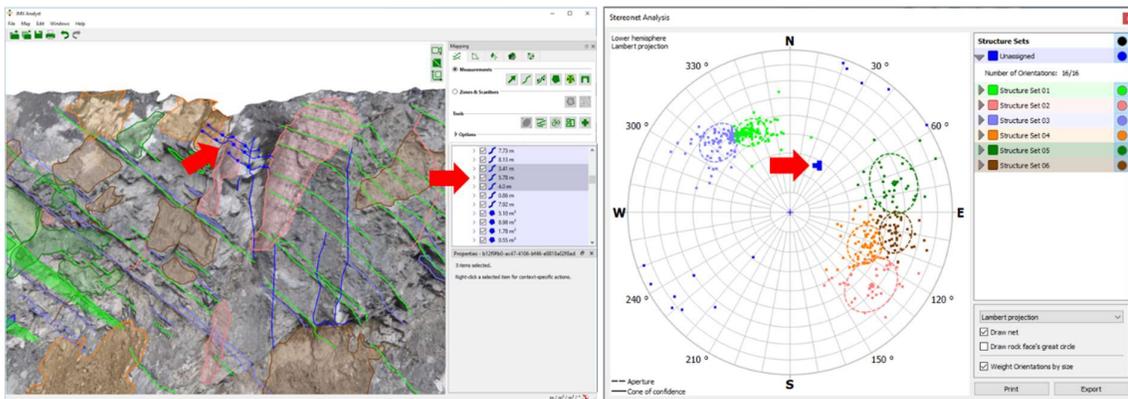

Figure 61: Selection of single poles in the hemispherical plot using the left mouse button. The corresponding entries are highlighted in the Structure List and on the 3D model. The measurements are found on the 3D model using the "Seek to" function of the context menu for the Annotation Element.

The hemispherical plot is saved as image ("*.png*" file) by clicking with the right mouse button somewhere in the viewer. A click on "*Save as Image*" opens a dialog to title the plot and to select the directory so save on the computer. Statistics can be printed using the "*Print*" button or exported to a file in "*.csv*" format using the "*Export*" button. The "*.csv*" files can be imported by any spread sheet application like MS Excel. The file starts with a header row, then following a row containing the name of the *Structure Set*, a row with the *Structure Set* statistics, and then several rows with the individual *Orientation* measurements. Any subsequent *Structure Set*s are separated by a blank row. The decimal point is the comma while the separator is the semicolon (in the English version of the software). The structure of the "*.csv*" export data file is the following:

Header row (one per file):
dip direction, dip angle, spherical aperture, concentration parameter, percentual degree of orientation, cone of confidence, confidence, number of orientations
Structure Set row (one per Structure Set):
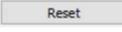Structure Set name
Statistic row (one per Structure Set):
2 numerical values: dip direction, dip angle

4.15 Automatic Joint Set Clustering

Joint Set Clustering is used to group measured structures automatically into *Structure Sets. Clustering* is based on a fuzzy K-means algorithm. It aims to minimising the distance measures between mean values of the *Structure Sets* and the individual measurements (objective function). The implementation within the *Analyst* considers orientations of measurements of structures (*Orientations*, *Traces* and *Areas)*. Thus, the implementation minimises the angles between the mean orientation and the individual orientations within a *Structure Set.* It uses a random set of initial values.

A fuzzy K-means algorithm requires a predefined number of clusters in which the data set shall be grouped. It iteratively recalculates the mean orientations and regroups the data set based on the current distance measures. The solution corresponds to the minimum value of the objective function obtained from a variation of initial values. The optimum number of clusters is a priori not known. Hence the fuzzy K-means algorithm is executed several times with a different number K of predefined clusters. In order to judge the optimum number of clusters a partitioning criterion is applied. The result with the optimum partitioning is suggested. Other results can be displayed on user interaction. The partitioning criterion examines the angular distance between all possible pairs of cluster mean orientations. If the angle exceeds the vector sum of the spherical aperture plus the cone of confidence of each set, the partitioning is counted as statistically significant. The result with the optimum partitioning has a maximum of significantly separated pairs, normalised by the compared number of pairs.

Standard operating procedure:

1. Click on the "*Clustering*" ⊞ icon in the toolbar of the *Structure* tab of the *Mapping* pane or chose "*Window | Stereonet Analysis*" in the menu bar

2. The *Clustering* dialog (Figure 62) appears which shows the poles of the measured *Orientations* discriminated for each *Structure Set* together with the cone of confidence and the spherical aperture. Typically, the map comprises only one *Structure Set* before clustering.

3. Define the configuration of Clustering:

   • *Cluster count:* Defines the number *K* of clusters. An upper and lower limit has to be defined. Only configurations within the defined bracket will be investigated.

   • *Membership angle*: Defines a limit beyond which an *Orientation* is no longer considered to be within the cluster

   • *Confidence*: Influences the size of the cone of confidence and affects the statistical cluster separation

   • *Weight Orientations by size*: *Analyst* allows to enable weights for each measurements. The weights are related to the maximum diameter of the structure. In consequence, large structures have more impact on the mean set orientation than small structures. The mean orientation vector of a *Structure Set* is then the sum of all weighted *Orientation* measurements contained in the *Structure Set*. "*Weight Orientations by size*" is enabled by ticking the corresponding checkbox.

4. Click on the "*Cluster*" [Cluster] button and clusters are determined (Figure 63)

5. Check the clustering result by inspecting the result for different clusters. You can switch between the results by selecting the corresponding number of clusters from the pull down menu (see Figure 63). The *Cluster Quality Measures* help in judging the optimum cluster configuration (see Figure 64 and information below).

6. Confirm result by clicking on the "*Accept selected Result*" [Accept selected Result] button or reset the *Clustering* by clicking the "Reset" [Reset] button

Note:

Annotation Elements of a *Structure Set* are excluded (locked) from clustering by enabling the corresponding checkbox "*Locked (when clustering)*" ☑ Locked (when clustering) in the *Properties* pane of the *Structure Set* (see Chapter 4).
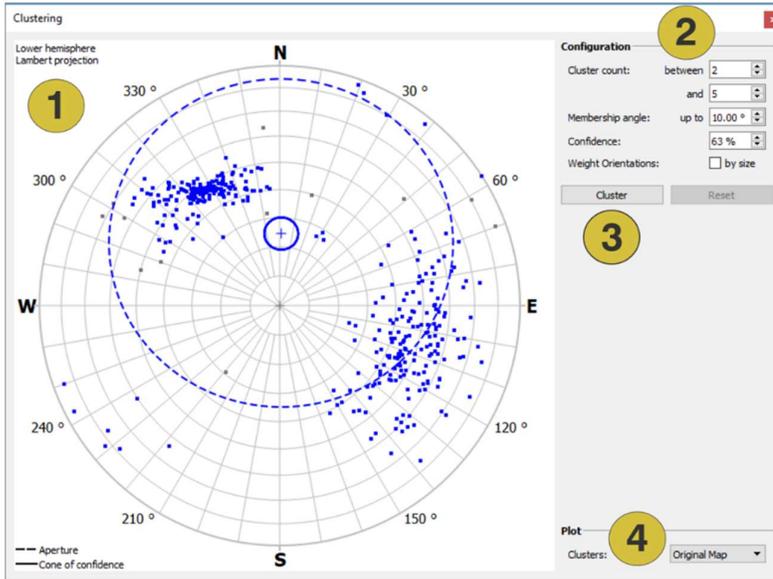
1 Projection of the lower hemisphere

2 Configuration

3 Cluster

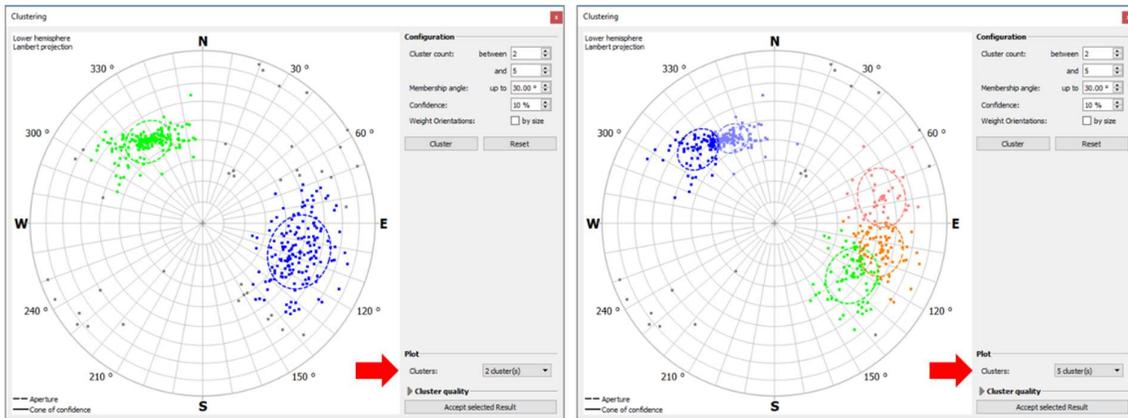**4** View results

Figure 62: Clustering

Figure 63: Example of Clustering

The quality of *Clustering* is reviewed by following *Cluster Quality Measures*:

- *Fuzzy Hypervolume* (min): Clusters shall occupy a minimum of the parameter space. The value shall be minimal.

- *Average Partition Density* (max): Poles shall be well-concentrated around the mean set orientation. The value shall be maximal.

- *Partition Density* (max): Poles shall be well-concentrated around the mean set orientation. The value shall be maximal.

- *Xie-Beni Index* (min): Tests the overall compactness and cluster separation. The value shall be minimal.

- *Fukuyama-Sugeno Index* (min): Relates the values of the fuzzy cluster objective function with the "cost" of increasing the numbers of clusters. The value shall be minimal.

Based in the provided information the user can judge the results and choose the optimum clustering result. Further reading for clustering background:

- Hammah, R. & Curran, J. (1998). Fuzzy Cluster Algorithm for the Automatic Identification of Joint Sets. *Int. J. Rock Mech. Min. Sci.* 35(7), 889-905.

- Wallbrecher, E. 1986. *Tektonische und gefügeanalytische Arbeitsweisen*, Enke, Stuttgart, 244pp
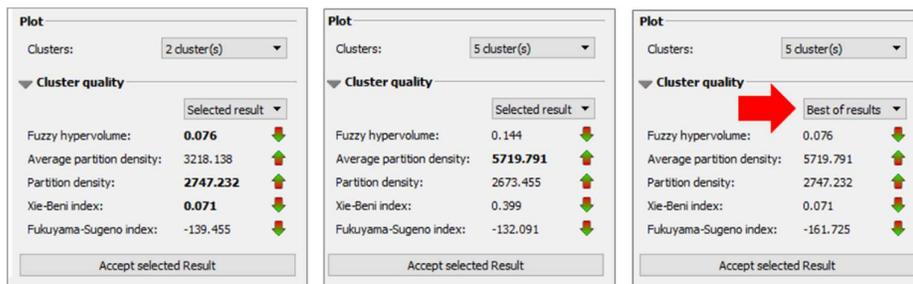

Figure 64: The cluster quality is given by Cluster Quality Measures. The user can switch between the different cluster results in the pull down menu whereas to values are given below.

The hemispherical plot is saved as image (".png" file) by clicking with the right mouse button somewhere in the viewer. A click on "*Save as Image*" opens a dialog to title the plot and to select the directory so save on the computer.

After the first clustering of a *Structure Set,* a so-called *Unassigned Set,* is added to the *Structure List.* The *Unassigned Set* contains *Annotation Elements* without an *Orientation*. Consequently the *Unassigned Set* does not provide any *Orientation Statistics*. The following *Annotation Elements* are assigned to the *Unassigned Set*:

- *Areas* without orientation

- *Traces* without orientation

- *Tape*

- *Bridges*

- *Measuring Points*

- Outliers

Usually, each *Annotation Elements* with an *Orientation* is assigned to a cluster. Outliers are filtered by defining the maximum membership angle. The "*maximum membership angle" (*see Figure 62*)* defines a limit beyond which a measurement is no longer considered to be within the cluster and assigned to the *Unassigned Set*.

Hint:

If all measurement shall be clustered to a *Structure Set,* the maximum membership angle has to set to 90°. The lower the maximum membership angle has been defined, the more variation of the results is induced in the individual evaluations. It is recommended to avoid maximum membership angles lower than 25°.

5 Geometry

Note:

Geometry Measurements i.e. *Volumes*, *Tape*, *Measuring Points*, and *Sections*, are managed in individual lists in the *Geometry* tab of the *Mapping* pane.
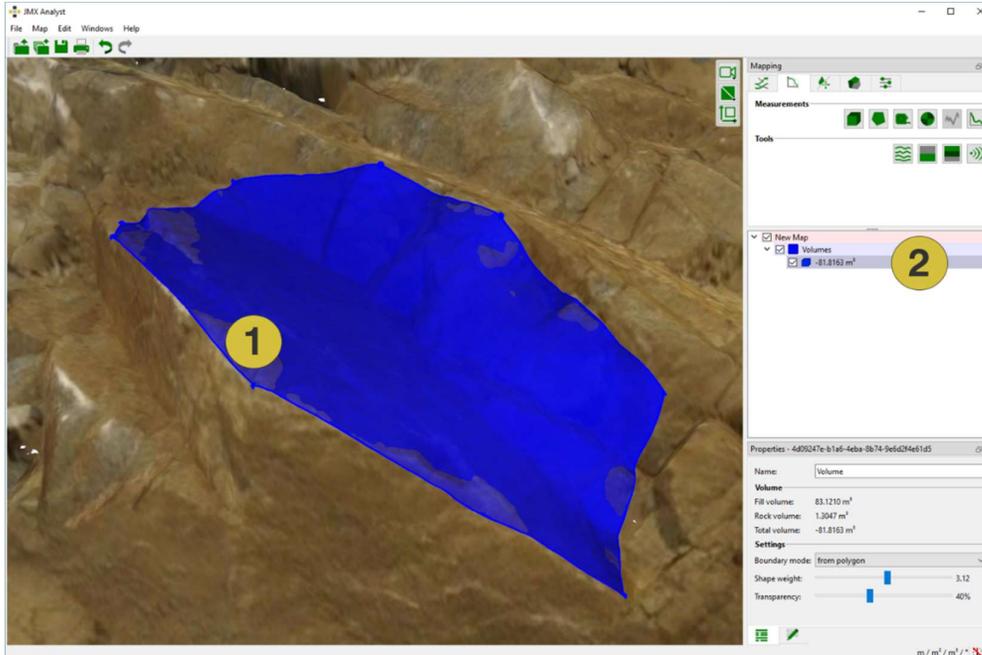
5.1 Volume

Analyst features the volume estimation of moulds delineated by a polygon on the 3D model (Figure 65). The Volume feature uses a user-defined polygon (area), the volume body is formed bases in the polygon and the interpolated with an uneven surface. The uneven surface closes the volume body with the interpolated surface and the 3D model surface.

Standard operating procedure:

1. Click on the "*Volume"* 🔲 icon in the toolbar of the *Geometry* tab or use the shortcut key "*V*"

2. Draw an area (as described in Chapter 4.5) on the 3D model by subsequently clicking on the 3D model with the left mouse button. The drawn area has the following properties:

   - The area encloses the prospective volume body along the 3D model

   - The area forms an artificial surface for closing the prospective volume body

6. Finish the *Volume* measurement and continue the mapping by pressing the "*Space"* key **or** finish the *Volume* measurement by clicking "*Enter*" or by clicking the "*Volume*" 🟩 icon (Figure 65). The calculated volume is provided instantly in an individual list in the *Geometry* tab.

Edit the *Volume* measurement by a double click with the right mouse button on the item:

- Insert a point by holding "*Ctrl*" and the right mouse button

- Delete a point by clicking "*Alt*" and the right mouse button

- Open the area by clicking "*Alt*" and the right mouse button and a click on the polygon

- Move a point by clicking "*Shift*" and the right mouse button

1 Volume

**2** Value of total volume

Figure 65: Volume measurement

Figure 66 shows *the Properties* pane for *Volumes*. The pane is activated in the context menu with "*Show Properties"* or by a click on "*Windows | Properties"* in the menu bar. It comprises:

- *Name of the Volume*

- *Volume:*

    o *Fill Volume*: Volume enclosed by the area and 3D model lying in front of the 3D model ("in front of the rock mass")

    o *Rock Volume*: Volume enclosed by the area and 3D model lying behind the 3D model ("in the rock mass")

    o *Total Volume*: Calculated total volume (difference calculation between rock volume and fill volume)

- *Settings:*

    o *Boundary Mode*:

        ▪ From clicked points: Artificial surface is calculated from the points clicked by the user on the 3D model. In case of "from clicked points, only the clicked points will from part of the interpolated surface, and lateral gaps are closed in direction of project from current view.

▪ From polygon: Artificial surface is calculated from polygon points along the 3D model. It is giving a more detailed set of points along the 3D model surface y sampling a dense set of points along the 3D model surface which is used for interpolation.

o *Shape Weight*: The slider is used to change the shape of the artificial surface. The interpolation surface is formed from a "median plane". The Shape weight is a weight on the points used for interpolation and it affects a kind of zone of influence of each point and thus governs the deviation from the median plane. If the weight is set to 1, then the points have only a small zone of influence and appear as "spikes" from the median plane, while if you increase the shape weight the zone of influence of each point increase and the interpolation surface becomes smoother and undulating.

o *Transparency*: The slider is used to change the transparency of the volume annotation

The name of the *Volume* can be edited in order to use an intuitive name or for more detailed descriptions. Customized notes can be added to individual *Tapes* in the *Notes* ✐ tab.
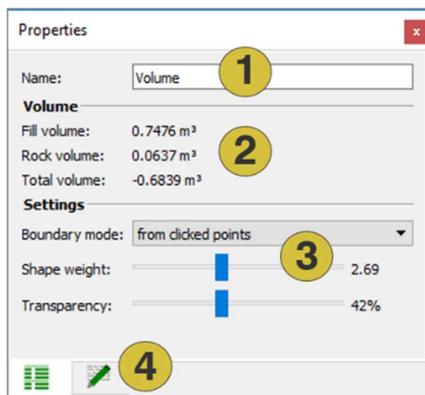
1 Name of the *Volume* (editable)
2 Calculated volume
3 Settings (editable)
4 Notes (editable)

Figure 66: Properties pane for Volumes

Context menu:

- *Edit*
  Insert a point by clicking "*Ctrl*" and the right mouse button. Delete a point by clicking "*Alt*" and the right mouse button. Open the area by clicking "*Alt*" and the right mouse button and a click on the polygon. Move a point by clicking "*Shift*" and the right mouse button.

- *Set Colour*
  Defines a new colour for the *Volume*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Volume* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Volume* in the 3D viewer

- *3D View-dependent Redraw*

  Redraws the *Volume* in subject to the current view

- *Delete*

  Deletes the selected *Volume*

- *Show Properties*

  Opens the *Properties* pane

- *Export*

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

5.2   Area Basic

The *Area Basic* mode is used for annotating area based structures (e.g. discontinuity surfaces) or for regions of common geological attributes. An area consists of a closed polygonal line that follows a discontinuity surface or any arbitrary portion of the surface. The *Area Basic* is slimmed version of the *Area* measurement (see Chapter 4.5). The position and size of the area is provided in the *Properties* pane. The pane is activated in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. Refer to Chapter 4.5 for further information. Short key *"A"* is assigned to the *Area Basic.*

5.3   Tape

The *Tape* allows determining an arbitrary stretch on the 3D model (Figure 67). The *Tape* provides values for lengths and distances including the length along the surface, the distance between starting and end point, the vertical distance and the horizontal distance.

Standard operating procedure:

1. Click on the "*Tape"* icon in the toolbar of the *Geometry* tab or use the shortcut key "*T*"

2. Mark the starting point for the measurement with a left button mouse click

3. Mark the end point for the measurement with a left button mouse click

4. If required, change the positions of the points by clicking with the left mouse button. The action affects the point closest to the mouse cursor.

5. Finish the *Tape* measurement and continue the mapping by pressing the "*Space"* key **or** finish the *Tape* measurement by clicking "*Enter*" or by clicking the "*Tape*" . The length along the surface is provided instantly in an individual list in the *Geometry* tab (see Figure 67).

Edit the *Tape* measurement by a double click with the right mouse button on the item and set a new start and/or end position of the *Tape* measurement by clicking the left mouse button.
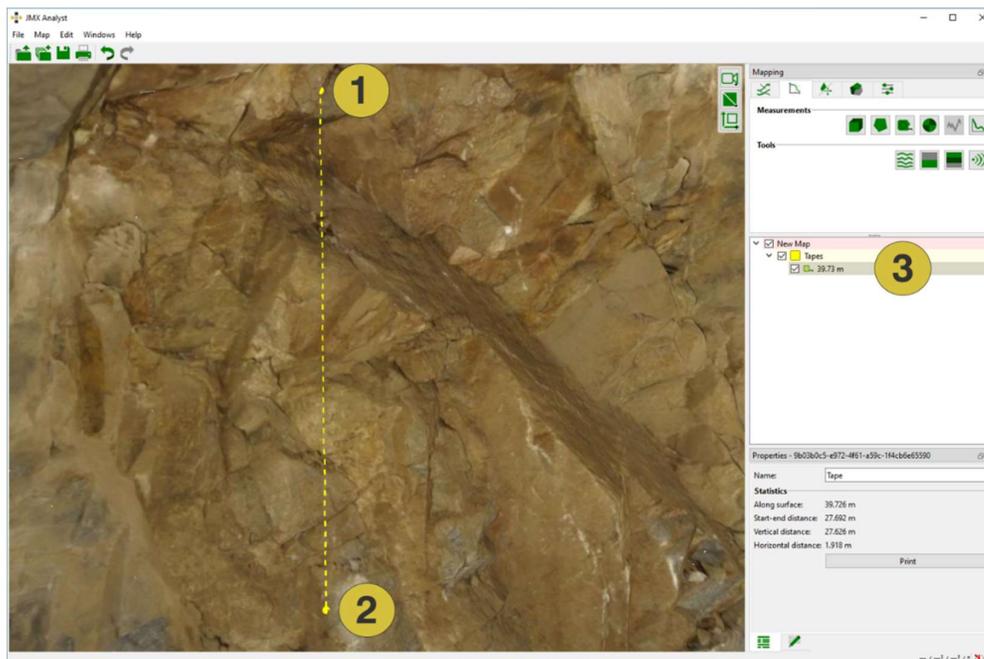
1   Start point
2   End point
3   Length (along surface)

*Figure 67: Tape (yellow dotted line) along a surface*

Figure 68 shows the *Properties* pane for the *Tape*. The pane is activated in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Tape*, and values for the lengths and distances including the length along the surface, the distance between starting and end point, the vertical distance and the horizontal distance. The name of the *Tape* can be edited in order to use an intuitive name or for more detailed descriptions. Customized notes can be added to individual *Tapes* in the *Notes* tab.
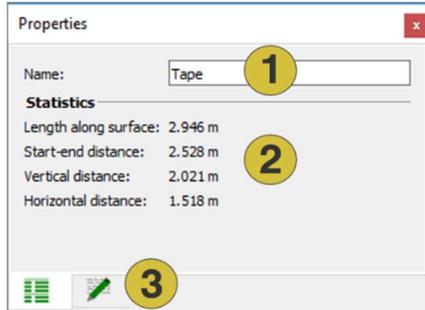
1 Name of the *Tape (*editable)

2 Statistics

3 Notes (editable)

Figure 68: Properties pane for Tapes

The *Plot* pane for *Tapes* contains the profile along the surface (Figure 69). The pane is activated in the context menu "*Show Plot*" or by a click on "*Windows | Plot*" in the menu bar. The reference line is the straight connection between the start point and end point. The profile can be shown exaggerated and not exaggerated depending on whether the scale switch is selected or unselected.
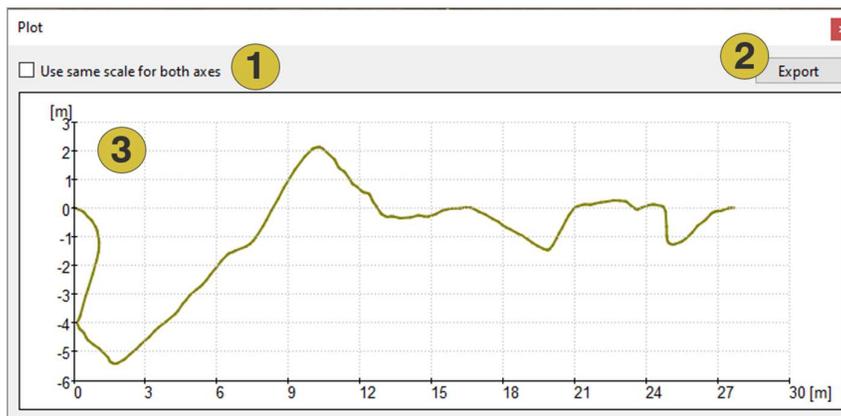
1 Scale width: Enable / disable the same scale for both axes

2 *Export* profile

3 Sketch of the profile

Figure 69: Plot pane for Tapes

The data of the profile can be exported by clicking the "*Export*" ⌑Export⌑ button. The export is possible in ".csv" and ".dxf" format:

- *CSV 2D*　　　Exports the plot transformed in 2D as "csv" file

  Header Row: distance; height
  Data row(s): 2 numerical values

- *CSV 3D*   Exports the the plot original in 3D as ".csv" file

   Header row: E, N, H
   Data row(s): 3 numerical values

- *DXF 2D*   Exports the plot as ".dxf" file

Context menu:

- *Edit*

  Moves one of the end points of the tape measure to a new position defined by a click with the left mouse button. The point closer to the mouse cursor is affected.

- *Set Colour*

  Defines a new colour for the *Tape*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Tape* measurement in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Tape* measurement in the 3D viewer

- *Delete*

  Deletes the selected *Tape*

- *Show Properties*

  Opens the *Properties* pane for the *Tape*

- *Show Plot*

  Opens the *Plot* pane for the *Tape*

- *Export*

   o *Export as DXF*   Exports the *Tape* as ".dxf" file

   o *Export as VRML*   Exports the *Tape* as ".vrml" file

5.4 Measuring Point

The *Measuring Point* provides the 3D co-ordinates of a single point of the 3D model (Figure 70). It is represented either in local co-ordinates or global co-ordinates depending on the reference frame of the 3D model.

Standard operating procedure:

1. Click on the "*Measuring Point*" ⬤ icon in the toolbar of the *Geometry* tab or use the shortcut key "*M*"

2. Mark the point for the measurement with a left button mouse click. Clicking on a different location resets the measurement.

3. Finish the measurement and continue the mapping by pressing the "*Space*" key **or** finish the *Measuring Point* measurement by clicking "*Enter*" or by clicking the "*Measuring Point*" ⬤. The co-ordinates of the *Measuring Point* are provided instantly in an individual list in the *Geometry* tab (Figure 70).

Edit the *Measuring Point* by a double click with the right mouse button on the item and set a new position of the *Measuring Point* by clicking the left mouse button.
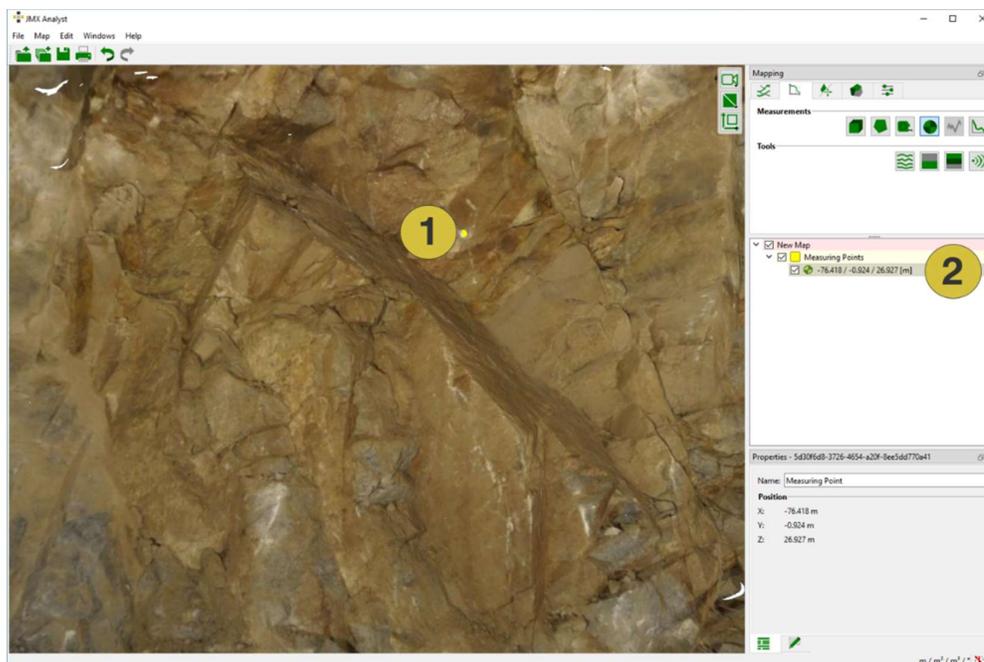
1   *Measuring Point*
2   Co-ordinates of the *Measuring Point*
Figure 70: Measuring Point (yellow spot)

Figure 71 shows the *Properties* pane for *Measuring Points*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Measuring Point* and co-ordinates. The name of the *Measuring Point* can be edited in order to use an intuitive name or for more detailed descriptions. Customized notes can be added to individual *Measuring Points* in the *Notes* 🖉 tab.
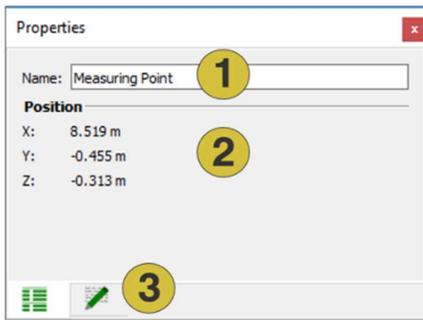
1 Name of Measuring Point (editable)

2 Co-ordinates

3 Notes (editable)

Figure 71: Properties pane for Measuring Points

Context menu:

- *Edit*

  Move the point by clicking the right mouse button

- *Set Colour*

  Defines a new colour for the *Measuring Point*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Measuring Point* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Measuring Point* in the 3D viewer

- *Delete*

  Deletes the selected *Measuring Point*

- *Show Properties*

  Opens the *Properties* pane for *Measuring Points*

- *Export*

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

5.5   Profile

The *Profile* provides a vertical section through the 3D model (Figure 72). It follows a line defined by two points on the 3D model. The *Profile* provides the distance along the surface and the (Euclidean) distance between the starting and end points of the *Profile*.
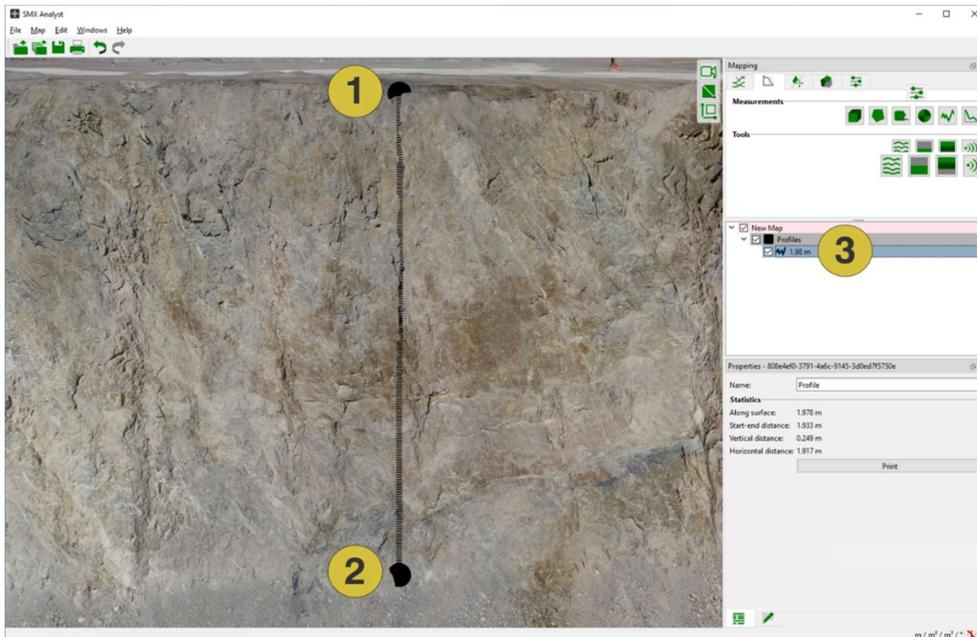
Note:

The *Profile* measurement is activated only if the 3D model has been scaled using the *MulitPhoto´s Sample Mode* (see corresponding manual). Thus, the section plane is assumed to be perpendicular to the xy plane.

Procedure:

1. Click on the *"Profile"* icon in the toolbar of the *Geometry* tab or use the shortcut key *"P"*.

2. Mark the starting point for the profile with a left button mouse click.

3. Mark the end point for the profile with a left button mouse click.

4. If required, change the positions of the points by clicking with the left mouse button. The action affects the point closest to the mouse cursor.

5. Finish the *Profile* measurement and continue the mapping by pressing the "*Space"* key **or** finish the *Tape* measurement by clicking "*Enter*" or by clicking the "*Profil"* . The length along the surface is provided instantly in an individual list in the *Geometry* tab (Figure 72).

Figure 73 shows the *Properties* pane for *Profiles*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Profile*, the length along the surface, start-end distance, vertical distance and the horizontal distance. The name of the *Profile* can be edited in order to use an intuitive name or for more detailed descriptions. The plot of the *Section* (see Figure 74) can be printed or saved as "pdf" by a click on the *"Print"* Print button. Customized notes can be added to individual *Profiles* in the *Notes* tab.

1 Start point

2 End point

3 Length along the surface

Figure 72: Profile (black dotted line)
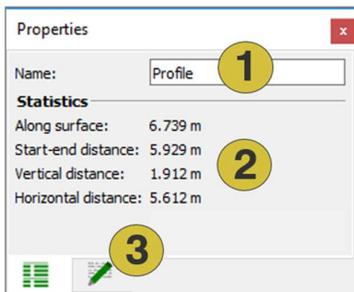
1 Name of the *Profile* (editable)

2 Statistics

3 Notes (editable)

Figure 73: Properties pane for Profiles

The *Plot* pane for *Profiles* contains the profile along the surface (Figure 74). The pane is activated in the context menu "*Show Plot*" or by a click on "*Windows | Plot*" in the menu bar. The reference line is the straight connection between the start point and end point. The *Profile* can be shown exaggerated and not exaggerated depending on whether the scale switch is selected or unselected.
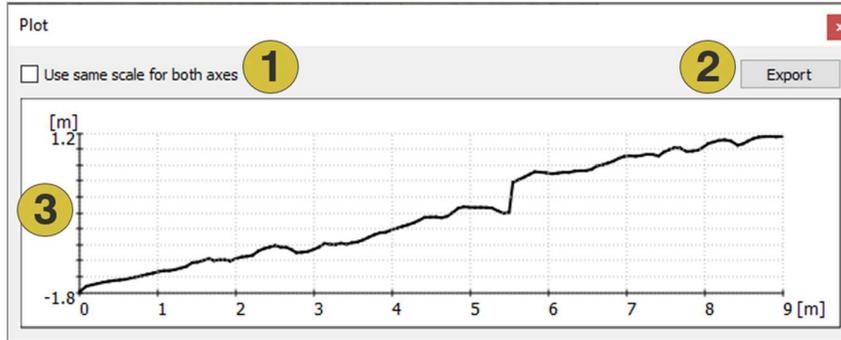
1 Scale width: Enable / disable the same scale for both axes

2 *Export* profile

3 Sketch of the profile

Figure 74: Plot pane for Profiles

The data of the profile can be exported by clicking the "*Export*" Export button. The export is possible in ".csv" and ".dxf" format:

- *CSV 2D*   Exports the plot transformed in 2D as "csv" file

  Header Row: distance; height
  Data row(s): 2 numerical values

- *CSV 3D*   Exports the the plot original in 3D as ".csv" file

  Header row: E, N, H
  Data row(s): 3 numerical values

- *DXF 2D*   Exports the plot as ".dxf" file

Context menu:

- *Edit*
  Moves one of the end points of the tape measure to a new position defined by a click with the left mouse button. The point closer to the mouse cursor is affected.

- *Active*
  Activates (shows) and deactivates (hides) the selected item

- *Look at*
  Centers the *Profile* in the 3D viewer

- *Look at and Zoom*
  Centers and zoom the *Profile* in the 3D viewer

- *Delete*
  Deletes the selected *Profile*

- *Show Properties*

  Opens the *Properties* pane for the *Profile*

- *Show Plot*

  Opens the *Plot* pane for the *Profile*

- *Export*

  - *Export as DXF*   Exports the *Profile* as ".dxf" file

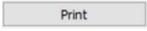 - *Export as VRML*   Exports the *Profile* as ".vrml" file

5.6 Section

A *Section* in the *Analyst* is a planar polygonal line formed by the intersection of a cutting plane and the 3D model (Figure 75). The cutting plane is defined by its position (three co-ordinates) and orientation (*Inclination* and *Strike Direction*). The software proposes a cutting plane after first editing. The user can edit the section type, the position and the orientation subsequently.

Standard operating procedure:

1. Click on the "*Section*" ⌐ icon in the toolbar of the *Geometry* tab or use the shortcut key "*S*". A *Section* including its cutting plane appears in the center of the 3D model. The used *Section* type is the same as with the last call of the function. The *Section* is active and editable.

2. Define the configuration of the *Section* in the *Properties* pane (Figure 76):

   a. Select the type of the *Section*: "*General"*, "*Vertical",* and "*Horizontal" Section*

   b. Move *Section* to the target position on the 3D model. Click with the left mouse button at the desired position on the 3D model or drag the *Section* there. The *Reference Point* on the plane is marked with a black dashed line.

   c. If necessary, adjust the orientation of the *Section*. Change "*Inclination"* and/or "*Strike direction"* of the cutting plane by entering the desired values in the editable fields or by scrolling the mouse wheel (see Chapter 3.5).

3. Confirm the *Section* and add another *Section* by pressing the "*Space"* key **or** finish the *Section* by clicking "*Enter*" or by clicking the "*Section*" ⌐. The *Section* is provided instantly in an individual list in the *Geometry* tab.

Edit the *Section* by a double click with the right mouse button on the item and set a new position of the *Section* by clicking the left mouse button.

Figure 76 shows the *Properties* pane for *Sections*. The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the

Section which can be edited in order to use an intuitive name or for more detailed descriptions and allows fast and instant editing of *Section* types and orientations. The *Section* type, i.e. *General Section*, *Vertical Section* or *Horizontal Section* can be selected by the activation of the corresponding radio button. In addition, editing the orientation of the *Section* in terms of inclination and strike direction is provided. The button ⟳180° changes the strike direction of the *Section* by 180°. The dialog also provides information about the position of the cutting plane. The plot of the *Section* (see Figure 80) can be printed or saved as "pdf" by a click on the *"Print"* Print button. Customized notes can be added to individual *Sections* in the *Notes* ✎ tab.
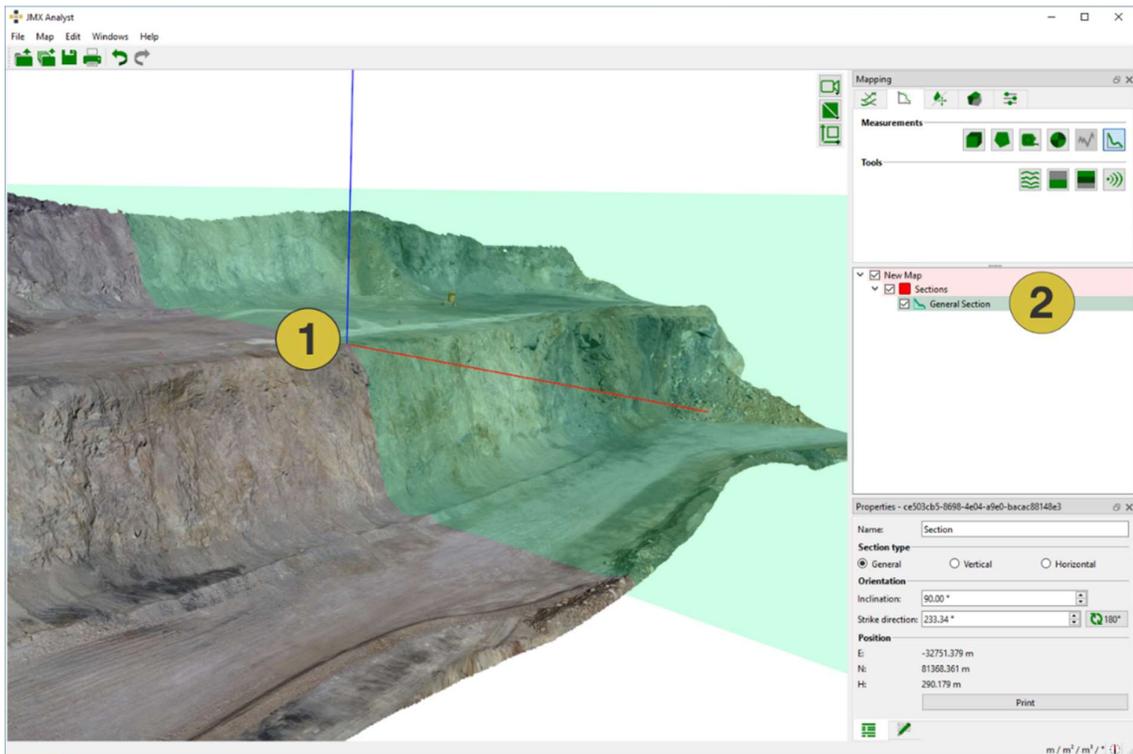
1   *General Section*

2   Entry in the list

Figure 75: Generation of a Section (green plane)

1 Name of the *Section* (editable)

2 Type of *Section* (editable)

3 Orientation parameters (editable)

4 Position

5 Print plot

6 Notes (editable)

Figure 76: Properties pane for Sections

Section Types (Figure 77):

- The *General Section* is formed by an arbitrarily orientated cutting plane whose orientation the user controls with inclination and strike direction*. General Sections* appear in cyan on the 3D model.

- The *Vertical Section* is formed by a vertical *Cutting Plane*. The user controls the strike direction while inclination remains at 90°. *Vertical Sections* appear in magenta on the 3D model.

- The *Horizontal Section* is formed by a horizontal *Cutting Plane.* The user controls the *strike direction* while *inclination* remains at 0°. *Vertical Sections* appear in blue on the 3D model.
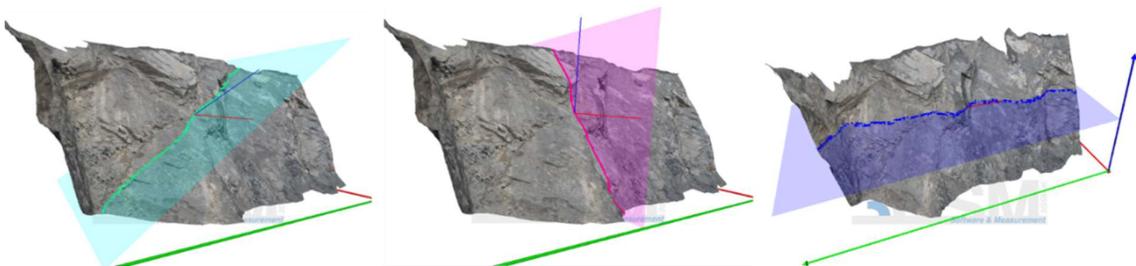
Figure 77: Section types: General Section in cyan (left), Vertical Section in magenta (middle) and Horizontal Section in blue (right)

Editing a Section:

- *Changing the position of a Section:* The position of is changed by moving the *Section* within the 3D viewer (in the *Edit* mode) while keeping the left mouse button pressed. The function "*Modify Section"* is called via the context menu of the *Section*. The new position is confirmed by pressing the return key or middle mouse button.

- *Changing the orientation of a Section:* The orientation is defined by "*Inclination" and "Strike Direction".* Inclination is changeable for *General Sections* only. Strike direction is changeable for *General, Vertical,* and *Horizontal Section*. The values are edited in the section *Properties* pane:

  - by entering the desired values

  - by turning the mouse wheel in the *Edit* mode

    - simple turning affects strike direction

    - turning together with pressing the "*Ctrl"* key affects inclination

  - by using the scrolling mechanism (see Chapter 3.5)

The new orientation is confirmed by pressing the return key or middle mouse button.

Cutting Plane

The *Cutting Plane* carries a defined co-ordinate system as is shown in Figure 78. It comprises the strike line (red), the negative dip line (blue), and the corresponding upward normal vector (not shown). The strike line remains in the *Cutting Plane* and is always horizontal. It is defined by the strike direction for all three, the *General Section, Vertical Section*, and *Horizontal Section.* The strike direction is the clockwise angle measured from the x-axis (local co-ordinate system of 3D model) / N-axis (global co-ordinate system of 3D model). Inclination is the angle measured from the xy-plane (EN-plane) downwards about the strike line. It is editable for the *General Section* only and predefined for the *Vertical* (90°) and *Horizontal* (0°) *Section*. The origin of the cutting plane's co-ordinate system is indicated by a black dashed vertical line (parallel to z / H-axis). The origin is always located on the 3D model, thus the intersection between *Cutting Plane* and 3D model always contains the origin. Figure 79 shows the *Cutting Plane* and the associated co-ordinate system in *Analyst*.
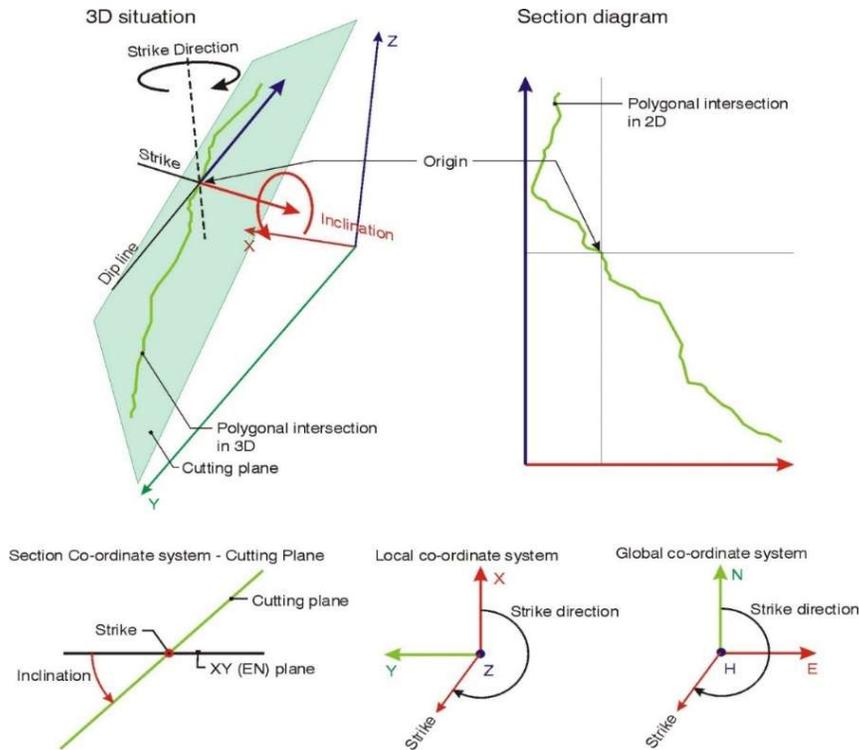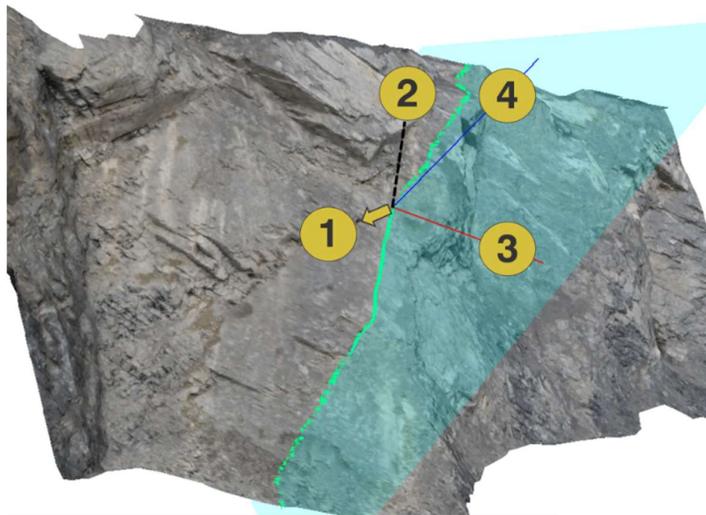
Figure 78: General relationships between co-ordinate system of 3D model and Section


1 Origin = *Reference Point*

2 *Reference Point* indicator (black dashed line)

3 Axis referring to the strike direction (red)

4 Axis referring to the negative dip direction (blue)

Figure 79: Section's cutting plane in Analyst

Plot and export of Sections

The plot of a *Section* (*Plot* pane see Figure 80) is a parallel projection of the cutting plane's co-ordinate system. The viewing direction is perpendicular to the cutting plane against the upward normal vector of the cutting plane's co-ordinate system. The projected strike line forms the abscissa and the negative dip line the ordinate of the section diagram. The origin of the *Section* diagram is contained within the polygon (except for geo-referenced vertical *Sections* where it shows the geo-referenced height instead of zero height). The *Plot* pane is opened in the context menu "*Show Plot*" or by a click on "*Windows | Plot*" in the menu bar. The profile of the *Section* can be shown exaggerated and not exaggerated depending on whether the scale switch is selected or unselected.

The data of the profile can be exported by clicking the "*Export*" [Export] button. The export is possible in ".csv" and ".dxf" format. The exported data comprises the polygonal line corresponding to the intersection between cutting plane and 3D model. Figure 81 shows the exported *Section* in ".csv" format transferred to a spreadsheet program (2D) and in ".dxf" format visualised in a dxf-viewer (3D). For the ".dxf" export it is necessary to define whether it shall be original 3D or transformed 2D. The 3D export considers the original intersection polygon in 3D co-ordinates. The 2D export transforms the data into a horizontal plane leaving the z co-ordinate in zeros. The plot of the *Section* can be printed or saved as "pdf" file by a click on the "*Print*" [Print] button in the *Properties* pane (see Figure 76).
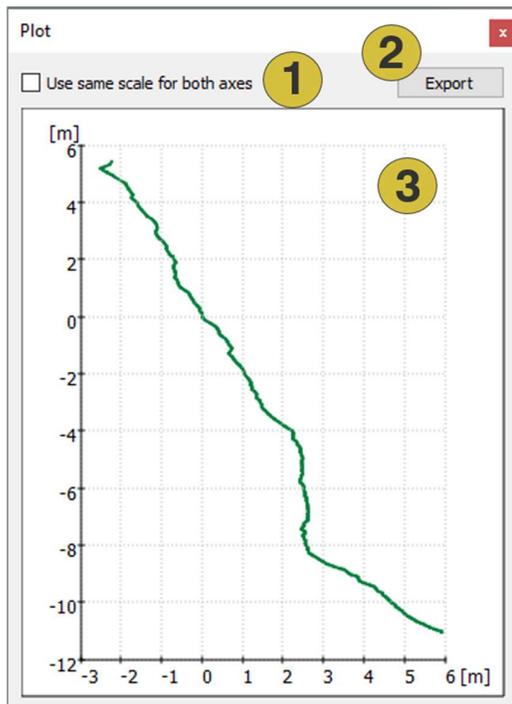
1   Scale width: Enable / disable the same scale for both axes
2   Export the profile
3   Sketch of profile
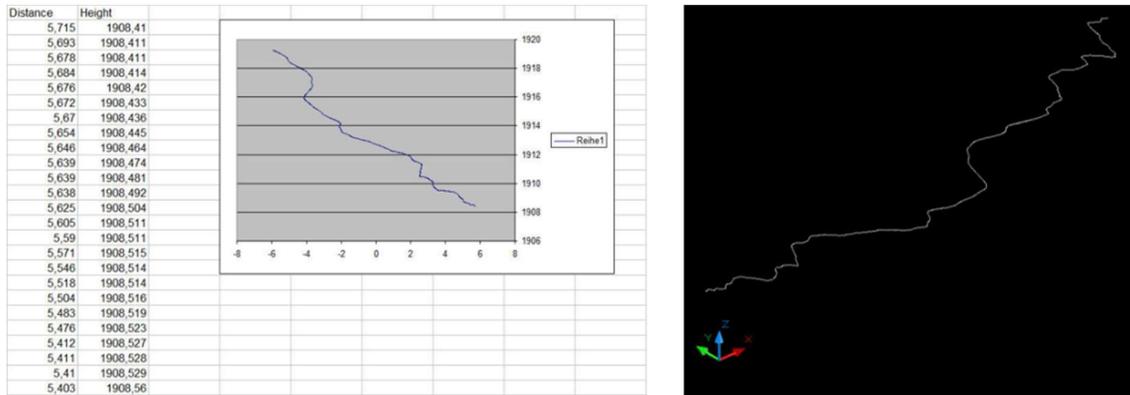
Figure 80: Plot pane for Sections

Figure 81: Exported Section to ".csv" file and transferred to a spreadsheet program (left). Exported Section displayed in a dxf-viewer (right).

Context menu:

- *Edit*

    Move the *Section* by clicking the left mouse button

- *Active*

    Activates (shows) and deactivates (hides) the selected item

- *Look at*

    Centers the *Section* in the 3D viewer

- *Look at and Zoom*

    Centers and zoom the *Section* in the 3D viewer

- *Delete*

    Deletes the selected *Section*

- *Show Properties*

    Opens the *Properties* pane for *Sections*

- *Show Plot*

    Opens the *Plot* pane for *Sections*

- *Export*

    o *Export as DXF*   Exports the *Section* as ".dxf" file

    o *Export as VRML*   Exports the *Section* as ".vrml" file

5.7   Contour Lines

The *Analyst* generates contour lines in respect to a user-definable projection plane (vertical, horizontal or general projection plane). Contour line properties are adjustable via the corresponding *Contour Lines* dialog (Figure 82).

Standard operating procedure:

1. Click on the *"Contour Lines"* ≋ icon in the toolbar of the *Geometry* tab of the *Mapping* pane

2. The *Contour Lines* dialog pops up showing the contour lines of the 3D model generated with the predefined settings. The dialog consists of the viewer, the *Options* side bar and buttons on the bottom right of the window.

The *Options* side bar offers the following functions:

- Range

    - *Start Level:* Lowest level at which *Contour Lines* are generated. Note that the lowest level may be defined below the lowest 3D model level.

    - *Stop Level:* Highest level at which *Contour Lines* are generated

    - *Step size:* Defines the vertical spacing between the *Contour Lines* in the current unit

- *Projection Plane*

    - *General*: generates contour lines in parallel to a user defined *general* plane with a user adjustable inclination and strike direction

    - *Vertical:* generates contour lines parallel to a vertical plane with a user adjustable strike direction

    - *Horizontal:* generates contour lines parallel to the ground plane of the 3D model

- *Plot*

    - *Contour values -* Properties of the elevation labels

        - *All*: Label for every contour line

        - *Bold Contours*: Labels only for bold contour lines

        - *None*: No labels

    - *Draw Bold Contours:* Turns bold contour lines on and off. If they are turned on, you can define the interval between the bold contour lines using the "*Every xxx Contours*".

    - *Filter Small Regions:* Turning on this function ignores small areas showing closed contour lines especially at nearly flat regions.

    - *Show Scale Bar:* Hide and shows the scale bar at the bottom left of the dialog

- o *Optimal Placement:* Rotates the plan view in order to maximise the plotted size of the *Contour Lines*

- o *Simplification:* Allows defining the degree of simplification by using the slider

Note:

Any changes of the *Contour Line* dialog affects also the overlay on the 3D model if it is enabled with selecting "*View | Show Contour Lines*" from the menu bar or by clicking the button *"Show in 3D Viewer"* in the *Contour Line* dialog (see Figure 83).
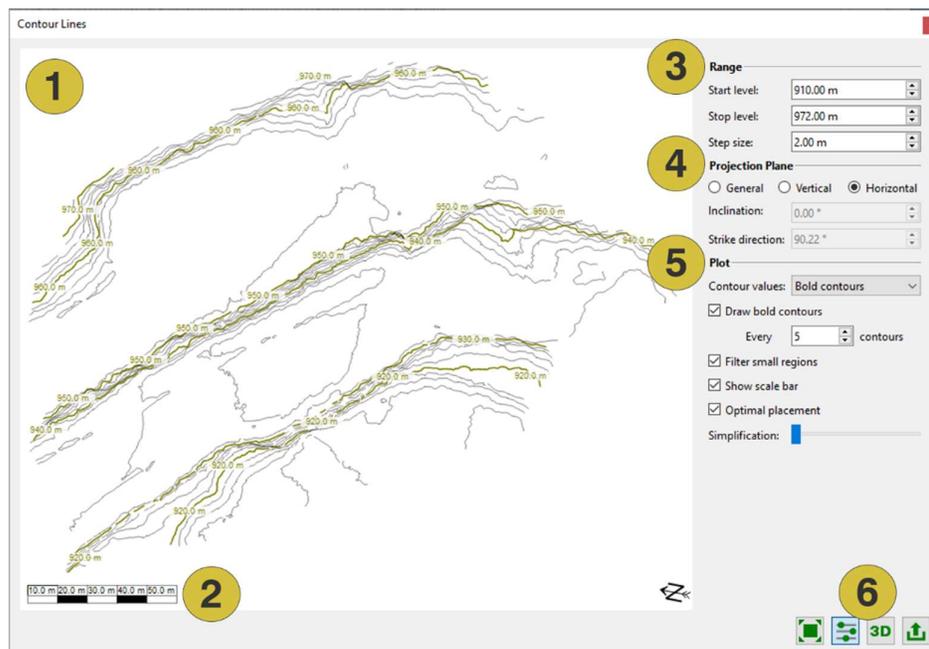
1   Plan view

2   Scale bar

3   Range

4   Projection plane

5   Plot options

6   Tool bar

Figure 82: Contour Lines

Figure 83: Contour lines visualized in the 3D viewer (left) and in the Contour Line dialog (right)

Navigation

- Relocation is performed by moving the mouse keeping the middle mouse button pressed

- Zooming is performed by turning the wheel of the mouse

- Reset zoom: The full image is visualized again by clicking the *"Reset Zoom"* button or by selecting the command *"View All"* in the context menu of the dialog.

Toolbar

Reset Zoom and Pan

　　　　　　　　　　　　　　　　　Resets the zoom

Options

　　　　　　　　　　　　　　　　　Hides/Shows the options side bar

Show on 3D Model

3D

　　　　　　　　　　　　　　　　　Shows or hides contour lines on the 3D model

Export

　　　　　　　　　　　　　　　　　Exports the contour line data as ".dxf" file

The plan view is saved as image (".png" file) by clicking with the right mouse button somewhere in the viewer. A click on "*Save as Image*" opens a dialog to title the plot and to select the directory so save on the computer.

5.8   Cutoff Plane

The *Cutoff Plane* is used to discriminate parts of the 3D model above and below the plane (Figure 84). The plane is parallel to the *Reference Plane* and has the same direction of the normal vector. The *Cutoff Plane* (see Figure 84) is activated by clicking the *"Cutoff Plane"* ▬ icon in the toolbar of the *Geometry* tab of the *Mapping* pane. Different colours are assigned to the parts above and below the plane and the corresponding total areas (in m^3) and relative areas (in %) are calculated.

The *Geometry* tab provides following information and configurations (Figure 85):

- *Distance to Reference Plane:* Defines the distance of the *Cutoff Plane* from the *Reference Plane*. It can be changed manually by entering the distance or by using the scrolling mechanism (see Chapter 3.5). Re-calculations of the areas are performed simultaneously by the software. See Figure 86.

- *Calculated area sizes:* Displays the area sizes above and below the *Cutoff Plane* in m^2 and percentage of the total area

- *Show Reference Plane:* Shows or hides the *Reference Plane* in the view

- *Show Cutoff plane:* Shows or hides the *Cutoff Plane* in the view

- *Show texture:* Activates or deactivates the texture of the 3D model

- *Report:* Prints a report which lists the available information and shows the corresponding picture of the 3D model

1 Area below the *Reference Plane*

2 Area above the *Reference Plane*

3 Configuration and information display

Figure 84: Cutoff Plane
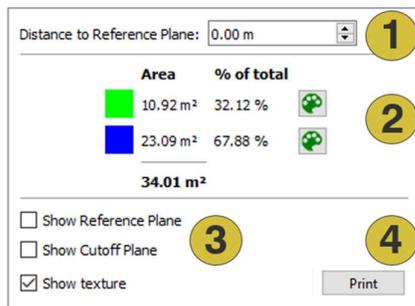
1 Distance to *Reference Plane*

2 Area partitioning

3 Viewer options

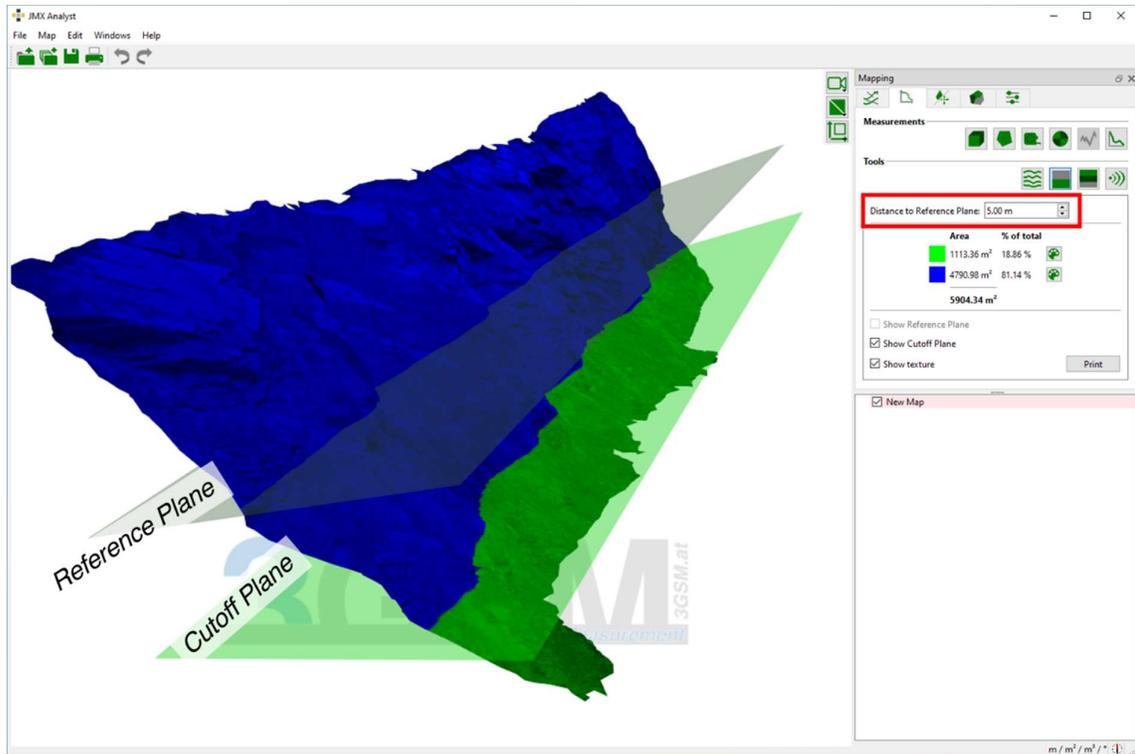**4** Print

Figure 85: Geometry tab: Cutoff Plane

Figure 86: Changing the position off the Cutoff Plane

5.9　Depth Colouring

The tool *Depth Colouring* features the colouring of the surface depending on the distance of the 3D model surface from the *Reference Plane* ("depth"). The false colour overlay is a tool for displaying irregularities of the surface. A legend illustrates the steps of the depth from blue to red. *Depth Colouring* is activated by a click on the "*Depth Colouring*" ▬ icon in the toolbar of the *Geometry* tab.

The selection "*User Defined*" allows the user to modify the maximum and minimum distance from the *Reference Plane*. Depths beyond these values are coloured in red and blue, respectively. It is also possible to define the number of increment steps. Using the selection "*Default*" the depth is displayed from the foremost to the backmost point using a continuous colour gradient (Figure 87). The *Reference Plane* is visualized by activating the *"Show Reference Plane"* checkbox in the *Geometry* tab or by a click on *"View | Show Reference Plane"* in the menu bar.
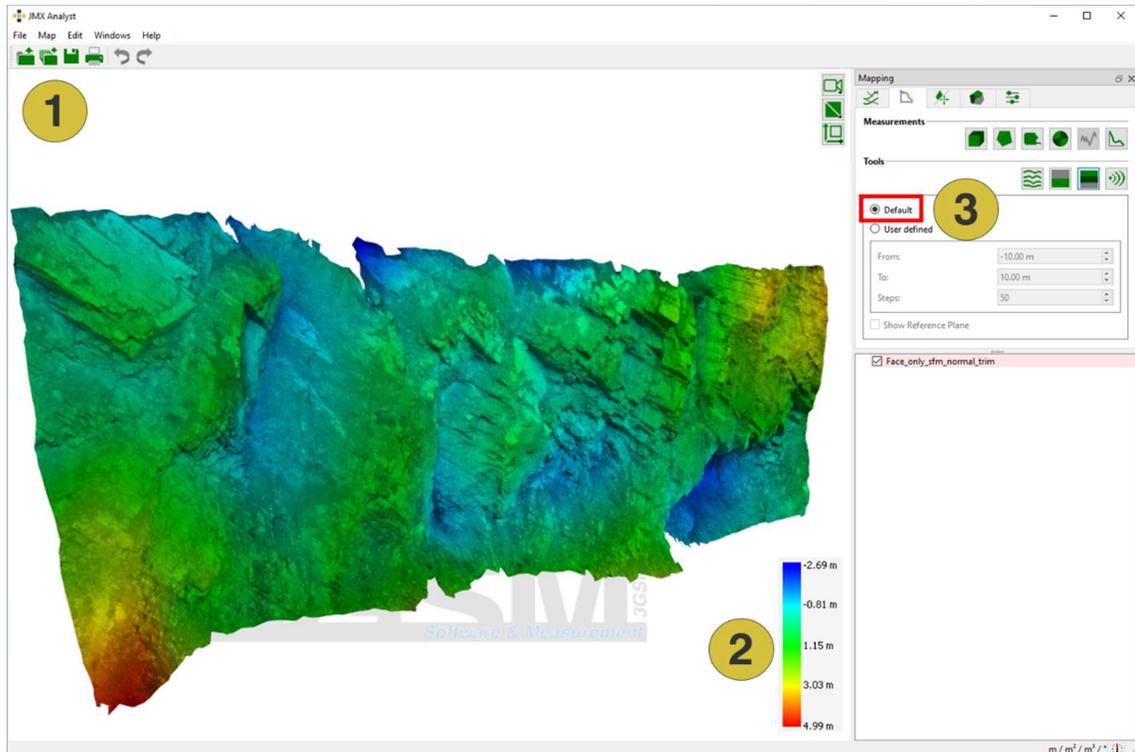
1   False coloured 3D model

2   Colour legend

3   *Depth Colouring* configuration

Figure 87: Depth Colouring "Default"

5.10 CSV 4D / Radar data

CSV 4D allows to import movement data from a ".csv" file provided from the *Guardian* software (*IDS GeoRadar*). The import includes co-ordinates of a point cloud with corresponding displacement data achieved from radar systems. A false colour overlay visualizes the displacement in the 3D viewer and the corresponding legend illustrates the steps of the displacement from blue to red (Figure 88). The feature offers the possibility to visualize geologic data along with radar data to help identifying mechanism that causes the displacement. *CSV 4D* is activated by a click on the *"CSV 4D"* ⋅⟩⟩ icon in the toolbar of the *Geometry* tab (*Mapping* pane).

The ".csv" data is loaded by clicking the "*Load*" button in the *Geometry* tab. After loading the data is immediately visualized by a false colour overlay and the number of loaded points is given in the *Geometry* tab. The colouring can be adapted by the user. Using the selection "*Default*" the displacement is visualized using a continuous colour gradient. The selection "*User Defined*" allows the user to modify the maximum and minimum distance and the number of incremental steps. It is possible to invert the colouring by enabling the corresponding checkbox *"Invert Colouring"* ☑ Invert colouring . The colour code changes to absolute values by enabling the checkbox "*Show absolute values*" ☑ Show absolute values. The *"Validity distance"* limits the visualization of the colour overlay. The entered value defines the maximum

distance between the 3D model and the loaded *CSV 4D* point cloud and excludes the visualization of areas with larger distances. Figure 89 shows an example of a user adapted visualization of displacement data.

Note:

The *CSV 4D* data is not saved in the *Map* ("*.jms*" file).
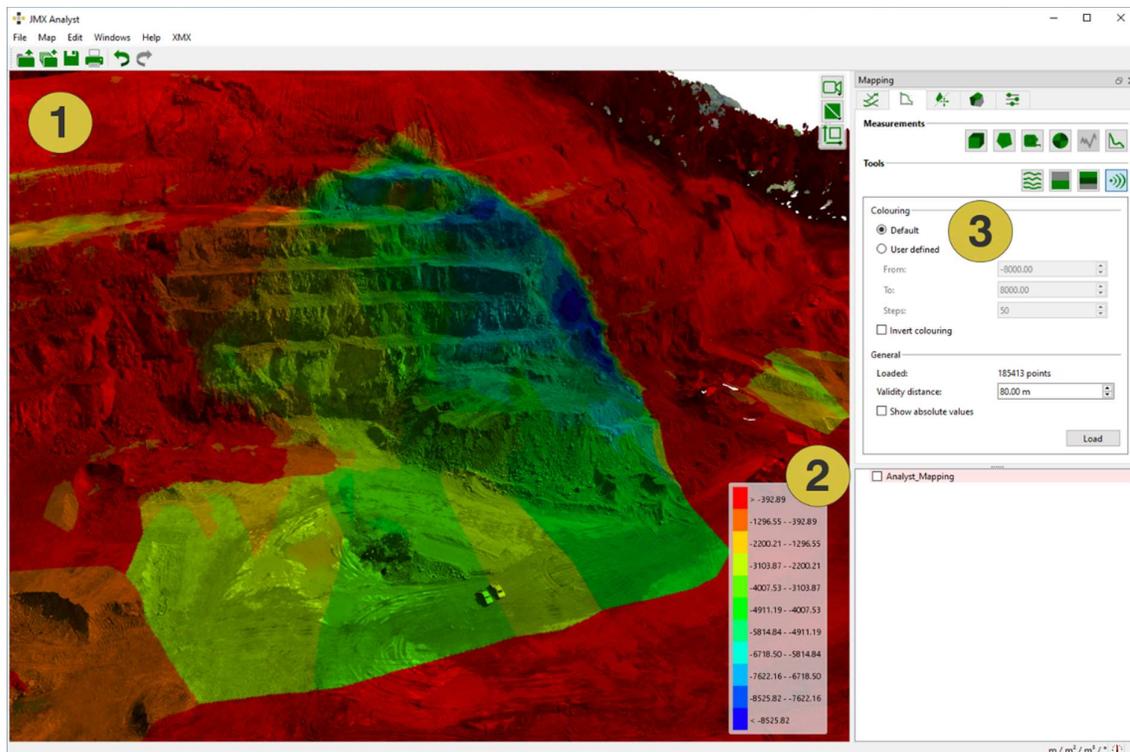
1 False colour overlay in the 3D viewer

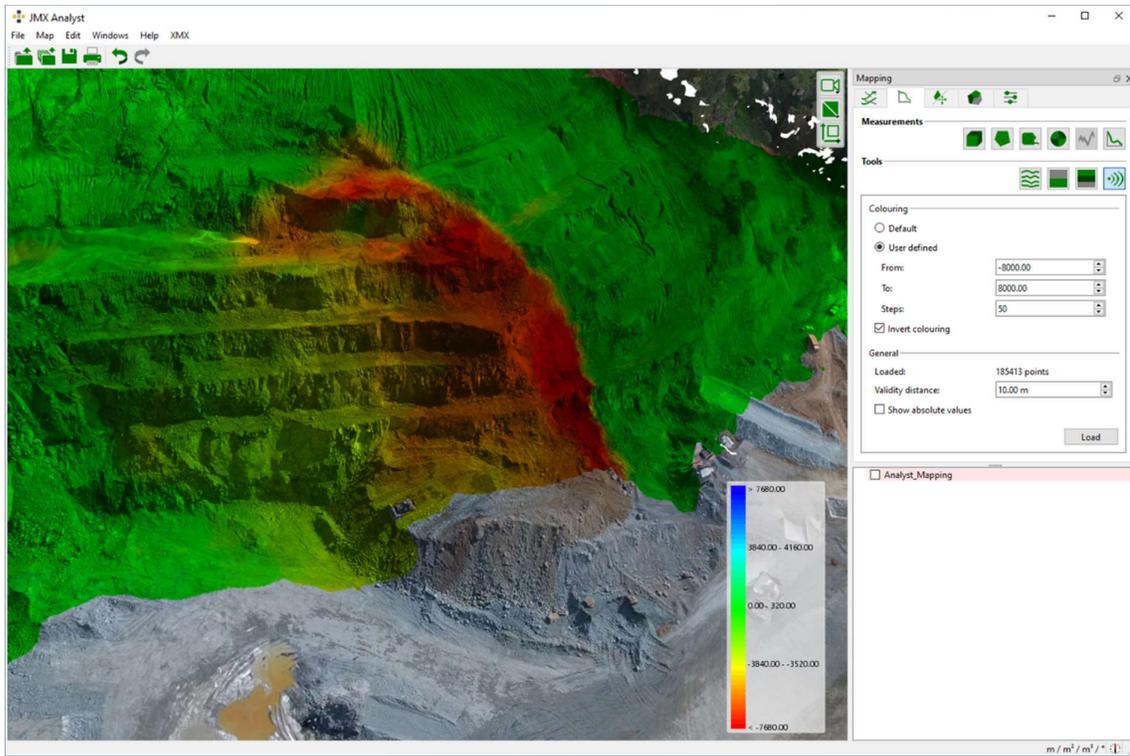**2** Colour legend

3 Configuration

Figure 88: CSV 4D import

Figure 89: User adapted visualization of CSV 4D data

6 Occurrences

The *Occurrences* tab comprises the *Option* dialog (Figure 90) which features to define a default water size (default radius). See Chapter 6.1 for further details.

▼ Options

Default size of Water: | 0.05 m | ⇳

Figure 90: Options dialog for Occurrences tab

6.1 Water

The *Water* annotation allows one to map water occurrence on the 3D model by a blue sphere indicator (Figure 91). Standard operating procedure:

1. Click on the "*Water*" 💧 icon in the toolbar of the *Occurrences* tab or use the shortcut key "*W*"

2. Mark the *Water* occurrence with a left button mouse click. Clicking on a different location resets the position

3. Finish the *Water* annotation and continue the mapping by pressing the "*Space*" key **or** finish the *Water* annotation by clicking "*Enter*" or by clicking the "*Water*" 💧 icon (Figure 91). The position is provided instantly in an individual list in the *Occurrences* tab.

Edit the *Water* annotation by a double click with the right mouse button on the item and set a new position of the *Water* annotation by clicking the left mouse button.
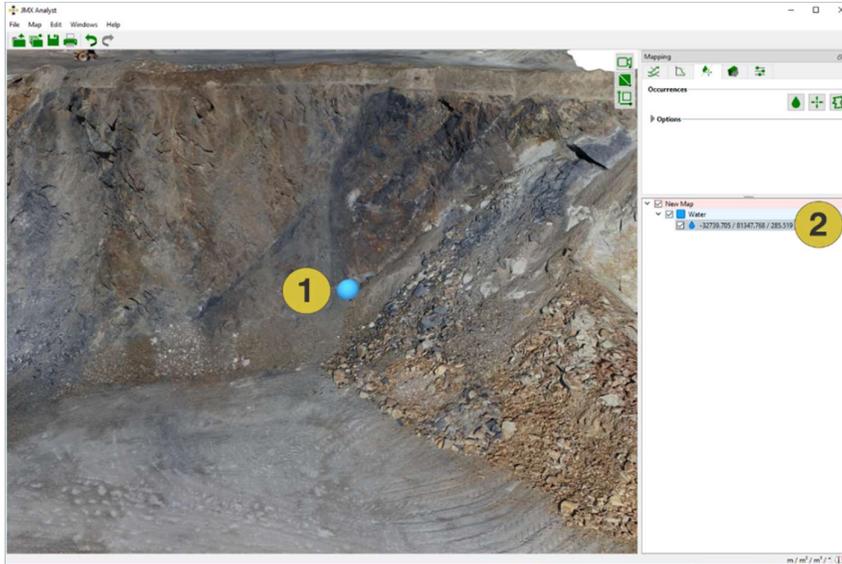
1 *Water* annotation

2 Position of the *Water* occurrence

Figure 91: Water annotation occur as a blue sphere. The Geometry tab shows the position in the co-ordinate system of the 3D model (E-N-H or x-y-z).

Figure 92 shows the *Properties* pane for the *Water* annotation. The pane is activated in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Water* annotation values for the co-ordinates of the position. The name of the *Water* annotation can be edited in order to use an intuitive name or for more detailed descriptions. The radius of the Water sphere is editable. A *Default size of the water* annotations can be defined in "*Options*" of the *Occurrences* tab. In addition the type i.e. undefined, wet spot or spring, and the ingress in [l/s] can be defined. Customized notes can be added to individual *Measuring Points* in the *Notes* 🖊 tab.
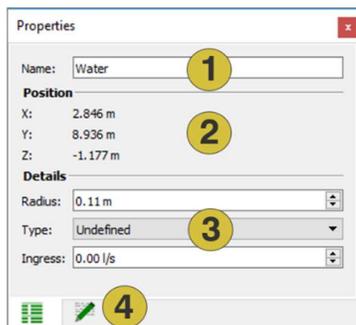
1 Name of *Water* annotation (editable)

2 Position

3 Properties (radius, type, ingress: editable)

4 Notes (editable)

Figure 92: Properties pane for Water annotations

Context menu:

- *Edit*

  Move the occurrence by clicking the left mouse button

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the occurrence in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the occurrence in the 3D viewer

- *Delete*

  Deletes the selected *Water* annotation

- *Show Properties*

  Opens the *Properties* pane for *Water* annotations

- *Export*

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

6.2   Punctual Occurrence

The feature *Punctual Occurrence* allows one to map a single event (occurrence) on the 3D model by a sphere (Figure 93). Standard operating procedure:

1. Click on the "*Punctual*" icon in the toolbar of the *Occurrences* tab or use the shortcut key "*P*"

2. Mark the *Punctual Occurrence* with a left button mouse click. Clicking on a different location resets the position.

3. Finish the *Punctual Occurrence* and continue the mapping by pressing the "*Space*" key **or** finish the *Punctual Occurrence* by clicking "*Enter*" or by clicking the "*Punctual Occurrence*" icon (Figure 93).

Edit the *Punctual Occurrence* by a double click with the right mouse button on the item and set a new position of the *Punctual Occurrence* by clicking the left mouse button.
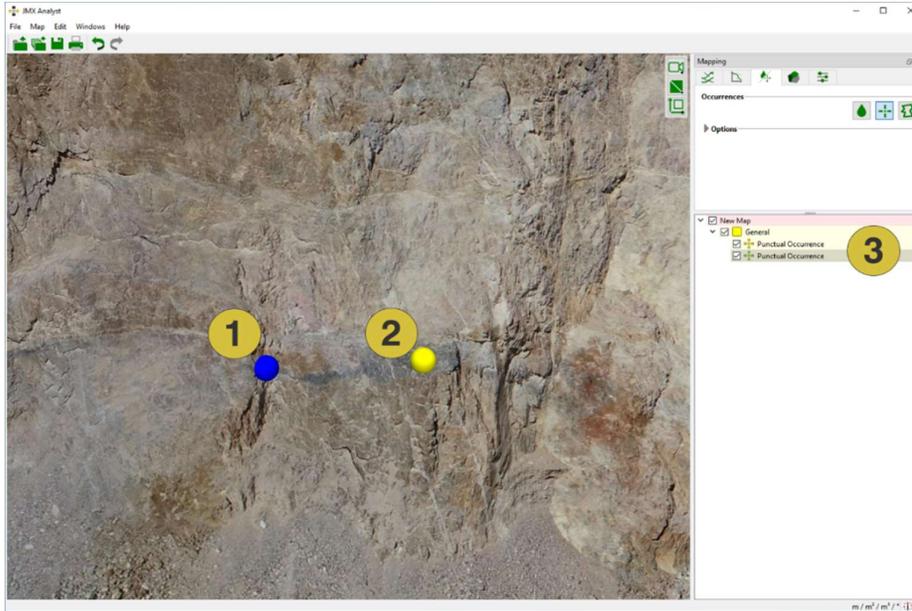
1 Active measurement (blue sphere)

2 Inactive measurement (yellow sphere)

3 *Punctual Occurrences* in the *Occurrences* tab with the active measurement highlighted

Figure 93: Punctual annotations

Figure 94 shows the *Properties* pane for *Punctual Occurrences.* The pane is opened in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. It comprises the name of the *Punctual Occurrence* annotation, co-ordinates of the position and the size of the annotation (editable radius of sphere). The name is editable in the in order to provide a descriptive name. Customized notes can be added to individual *Punctual Occurrences* in the *Notes* 🖉 tab.
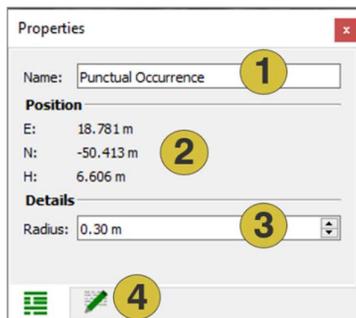
1 Name of *Punctual Occurrence* (editable)

2 Position

3 Radius of the sphere (editable)

4 Notes (editable)

Figure 94: Properties pane for Punctual Occurrences

Context menu:

- *Edit*

  Move the occurrence by clicking the left mouse button

- *Set Colour*

  Defines a new colour for the *Punctual Occurrence*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the occurrence in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the occurrence in the 3D viewer

- *Delete*

  Deletes the selected *Punctual Occurrence*

- *Show Properties*

  Opens the *Properties* pane for *Punctual Occurrences*

- *Export*

  - *Export as DXF*   Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file
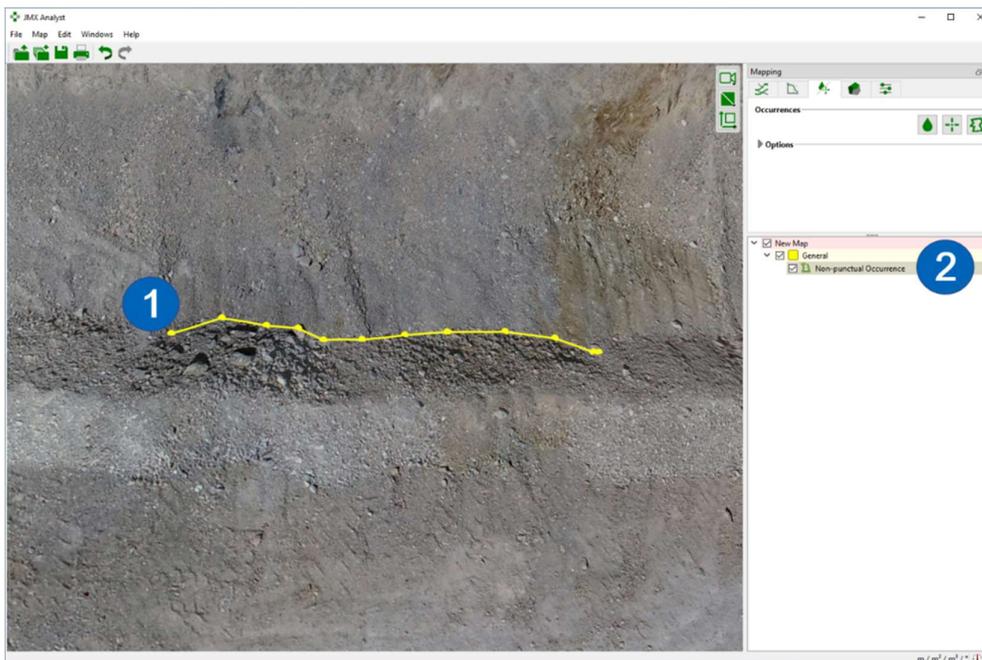
6.3   Non-punctual Occurrence

The feature *Non-punctual Occurrence* allows one to map an event on the 3D model by a polygon (Figure 95). Procedure:

1. Click on the *"Non-punctual Occurrence"* icon in the toolbar of the *Occurrences* tab or use the shortcut key *"N"*

2. Mark the *Non-punctual Occurrence* on the 3D model by clicking the left mouse button. A polygonal line is growing instantaneously. Undo the last action by pressing the right mouse button (multiple uses possible).

3. Finish the *Non-punctual Occurrence* and continue the mapping by pressing the "*Space"* key **or** finish the *Non-punctual Occurrence* by clicking "*Enter*" or by clicking the "*Non-punctual Occurrence"* icon (Figure 95).

Edit the *Non-punctual Occurrence* measurement by a double click with the right mouse button on the item:

- Add a point by clicking the right mouse button

- Insert a point by holding "*Ctrl*" and clicking the right mouse button

- Delete a point by holding "*Alt*" and clicking the right mouse button

- Move a point by holding "*Shift*" and clicking the right mouse button

The *Properties* pane for *Non-Punctual Occurrences* is activated in the context menu with "*Show Properties*" or by a click on "*Windows | Properties*" in the menu bar. The properties are displayed with a click in the corresponding entry in the *Occurrences* tab. The name of the *Non-Punctual Occurrence* can be edited in order to use an intuitive name or for more detailed descriptions. Customized notes can be added to individual *Non-Punctual Occurrences* in the *Notes* 🖉 tab.

1   Polygon of the *Non-punctual Occurrence*
2   *Non-punctual Occurrence* in the *Occurrences* tab
Figure 95: Non-punctual Occurrence (yellow polygon)

Context menu:

- *Edit*
  Add a point by clicking the right mouse button. Insert a point by holding "*Ctrl*" and clicking the right mouse button. Delete a point by holding "*Alt*" and clicking the right mouse button. Move a point by holding "*Shift*" and clicking the right mouse button

- *Set Colour*

  Defines a new colour for the *Non-punctual Occurrence*

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the occurrence in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the occurrence in the 3D viewer

- *Delete*

  Deletes the selected *Non-punctual Occurrence*

- *Show properties*

  Opens the *Properties* pane for the *Non-punctual Occurrence*

- *Export*

  - *Export as DXF* Exports the measurement as ".dxf" file

  - *Export as VRML*   Exports the measurement as ".vrml" file

7   Area partitioning

Analyst provides partitioning and quantification of user defined areas (*Lithologic Regions* and *Homogenous Areas*) on the 3D model.

7.1   Lithologic Region

The feature *Lithologic Region* allows to define different rock types on the 3D model. A *Lithologic Region* is an area which is split up into several segments each corresponding to a specific rock type. The region and its segments are delineated by polygons on the 3D model. Once a *Lithologic Region* is confirmed, the total area and the area of the particular segments in m^2 and the relative area in percentage is calculated. The segments can be assigned to individual rock types in the software. Rock types (name and colour) have to be defined in the *Mapping Definition File* (".pb" file) created in the *Start Window Settings* dialog launched from the center window of *ShapeMetriX* (see corresponding user manual).

Procedure: Step 1 – Add *Lithologic Regions* (Figure 96)

1. Click on the "*Lithologic Region*" 🗺 icon in the toolbar of the *Area Partitioning* tab or use the shortcut key "*L*".

2. Mark the border line of the *Lithologic Region* (entire region) on the 3D model by clicking the left mouse button. A polygonal line grows instantaneously.

3. Confirm the polygon by pressing the "ESC", "*Enter*" key or "*Space*" button. The area is automatically closed.

4. Split the area into segments by drawing:

    a. A polygon, which intersect the border of the *Lithologic Regio*

    b. A closed polygon inside the border of the *Lithologic Region*

5. Go on splitting the *Lithologic Region* until all segments have been defined.

6. Finish the *Lithologic Region* by pressing the "ESC", "*Enter*" key or "*Space*" button.

1 Drawing the border line of the Lithologic Region

2 *Lithologic Region* in the *Geometry* tab

3 Confirmed border line

4 Splitting up the area into segments

5 Confirmed *Lithologic Region*

Figure 96: Procedure of drawing a Lithologic Region

Procedure: Step 2 – Assign rock types to *Lithologic Regions* (see Figure 97)

7. Open the *Properties* pane for *Lithologic Regions* (if not already activated) by a click on "*Windows | Properties"* in the menu bar or in the context menu "*Show Properties".*

8. Choose the segment by a click on the corresponding area. The active area is highlighted in the 3D model (thick line) as well as in the *Properties* pane (bold letters).

9. Choose the rock type in the pull-down menu next to the calculated area values (total areas in m³ and relative areas in percentage) in the *Properties* pane. The area is re-coloured immediately in the 3D viewer after choosing the rock type.

10. Go on assigning the individual segments by repeating steps 8 and 9.

The *Lithologic Region* is displayed in form of a pie chart in the *Plot* dialog (Figure 98). Areas of equal rock types are combined in the plot by enabling the checkbox *"Combine types in plot"* in the *Properties* pane. Notification to each segment is gained by moving the cursor on it. The pane is activated in the context menu *"Show Plot"* or by a click on *"Windows | Plot"* in the menu bar.

1   Selection of segment (highlighted in the 3D viewer and in the *Properties* pane)

2   Name of the *Lithologic Region* (editable) in the *Properties* pane

3   Assignment of rock types from the pull down menu in the *Properties* pane

Figure 97: Lithologic Region with assigned rock types
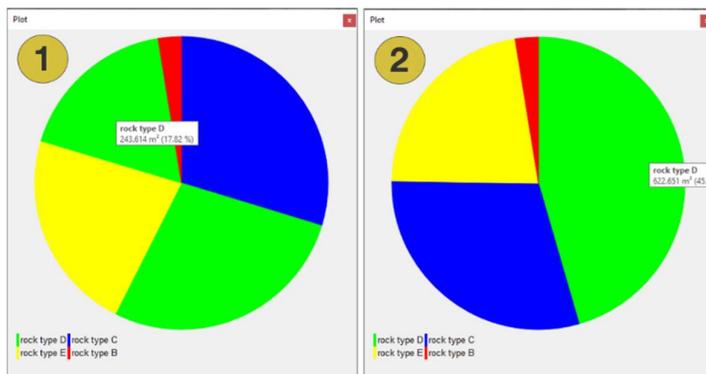
1   Pie chart of the *Lithologic Region*

2   Pie chart of the *Lithologic Region* with rock types combined

Figure 98: Pie chart of Lithologic Region in the Plot pane

Context menu:

- Edit
  Enters a new segment

- *Active*
  Activates (shows) and deactivates (hides) the selected item

- *Look at*
  Centers the *Lithologic Region* in the 3D viewer

- *Look at and Zoom*
  Centers and zoom the *Lithologic Region* in the 3D viewer

- *Delete*
  Deletes the selected *Lithologic Region*

- *Show properties*
  Opens the *Properties* pane for the *Lithologic Region*

- *Export*

  - *Export Area Partitioning Data as CSV*   Exports the *Lithologic Region* as ".csv" file

  - *Export as DXF*   Exports the data as ".dxf" file

  - *Export as VRML*   Exports the data as ".vrml" file

7.2   Homogenous Areas

The feature *Homogenous Area* allows to define segments with similar properties on the 3D model. A *Homogenous Area* is an area which is split up into several segments (i.e. area partitioning) each corresponding to specific properties. The region and its segments are delineated by polygons on the 3D model. Once a *Homogenous Area* is confirmed, the total area and the area of the particular segments in m^2 and the relative area in percentage is calculated. The individual segments can be assigned to customized types and colours.

Procedure:

1. Click on the *"Homogenous Area"* 🏠 icon in the toolbar of the *Area Partitioning* tab or use the shortcut key *"H"*

2. Generating and editing a *Homogenous Area* is similar to the generation of a *Lithologic Region* (see Figure 96 and Figure 97). Follow steps 2 to 8 in Chapter 7.1

3. Label and choose colours for the individual segments of the *Homogeneous Area* in the *Properties* pane

The *Homogeneous Area* is displayed in form of a pie chart in the *Plot* dialog (see Chapter 7.1, Figure 98). Notification to each segment is gained by moving the cursor on it. The pane is activated in the context menu *"Show Plot"* or by a click on *"Windows | Plot"* in the menu bar.

Context menu:

- Edit

  Enters a new segment

- *Active*

  Activates (shows) and deactivates (hides) the selected item

- *Look at*

  Centers the *Homogenous Areas* in the 3D viewer

- *Look at and Zoom*

  Centers and zoom the *Homogenous Areas* in the 3D viewer

- *Delete*

  Deletes the selected *Homogenous Area*

- *Show properties*

  Opens the *Properties* pane for the *Homogenous Areas*

- *Export*

  - *Export Area Partitioning Data as CSV*   Exports the *Homogenous Areas* as ".csv" file

  - *Export as DXF*   Exports the data as ".dxf" file

  - *Export as VRML*   Exports the data as ".vrml" file

8   Extras

8.1   Show contour lines

Contour lines are displayed with the command *"View | Show Contour Lines"* in the menu bar. The overlay of contour lines (Figure 99) accords to the spacing defined in the *Contour Lines* dialog (see Chapter 5.7).
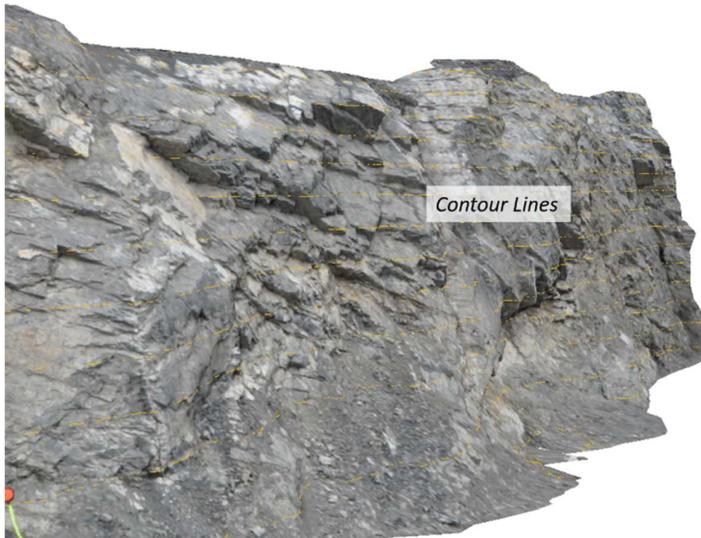
Figure 99: Contour lines overlay (yellow dotted lines)

8.2   Fullscreen view

The fullscreen view is called with the command in the menu "*View | Fullscreen"* or via the context menu of the 3D viewer (Figure 100). The full screen display is closed by unticking the "*Fullscreen"* command in the context menu or pressing the "*Esc"* key.

Figure 100: Fullscreen display

9 Import and Export

Analyst has several import and export functions thus significantly increasing its capabilities and use for geological and geotechnical engineering.

9.1 Import options

Import 3D model

Once a 3D model is loaded, another 3D model can be imported from the menu bar by selecting "*File | Import 3D Model*". It is assumed that all the imported 3D models are registered in the same co-ordinate system as the loaded 3D model. Figure 101 shows an example for several imported 3D models.

Figure 101: Several imported 3D models used for documentation of a drift tunnel excavation

Import Map

Several *Maps* can be imported on one or on several 3D models by selecting "*Map | Import | Import Another Map*" from the menu bar.

9.2 Export options

Export 3D model

Export configurations to each file format can be defined in the individual *Export* dialogs (see Figure 102). Following options are available:

- VMRL - "*File | Export | Export as VRML*": Writes a ".vrml" 2.0 file of the 3D model including points and triangulation. The texture is exported as separate bitmap file or can be embed in the exported file (enable *"Embed texture")*. The number of exported model points corresponds so the number

displayed model points as defined in the "*Edit | Options*" dialog. For further information refer to: http://en.wikipedia.org/wiki/VRML and http://www.web3d.org/x3d/vrml.

- DXF - "*File | Export | Export as DXF*": Writes a ".dxf" file of the triangulation of the 3D model. The number of exported model points can be defined.

- OBJ - "*File | Export | Export as OBJ*": Writes the co-ordinates of the points and triangulation into wavefront ".obj" files together with separate bitmap files for the texture.

- OBJ for Rocscience: "*File | Export | Export for Rocscience (OBJ)*": Writes the co-ordinates of the points and triangulation to ".obj" files together with a separate ortho-photo (Interface to the *Rocsience* software).

- 3GRS - "*File | Export | Export for Rocscience (Point cloud)*": Writes the co-ordinates of the 3D model points in a user defined resolution (interface to the *Rocsience* software). In addition, the dialog supports the export of structural-geologic mapping data in ".3gdps" format (interface to the *Rocsience* software) by enabling the checkbox "*Export Map*".

- CSV - "*File | Export | Export Points*": Writes an ASCII comma separated value file (".csv") of the co-ordinates of the point cloud. The number of exported model points and the separator can be influenced.
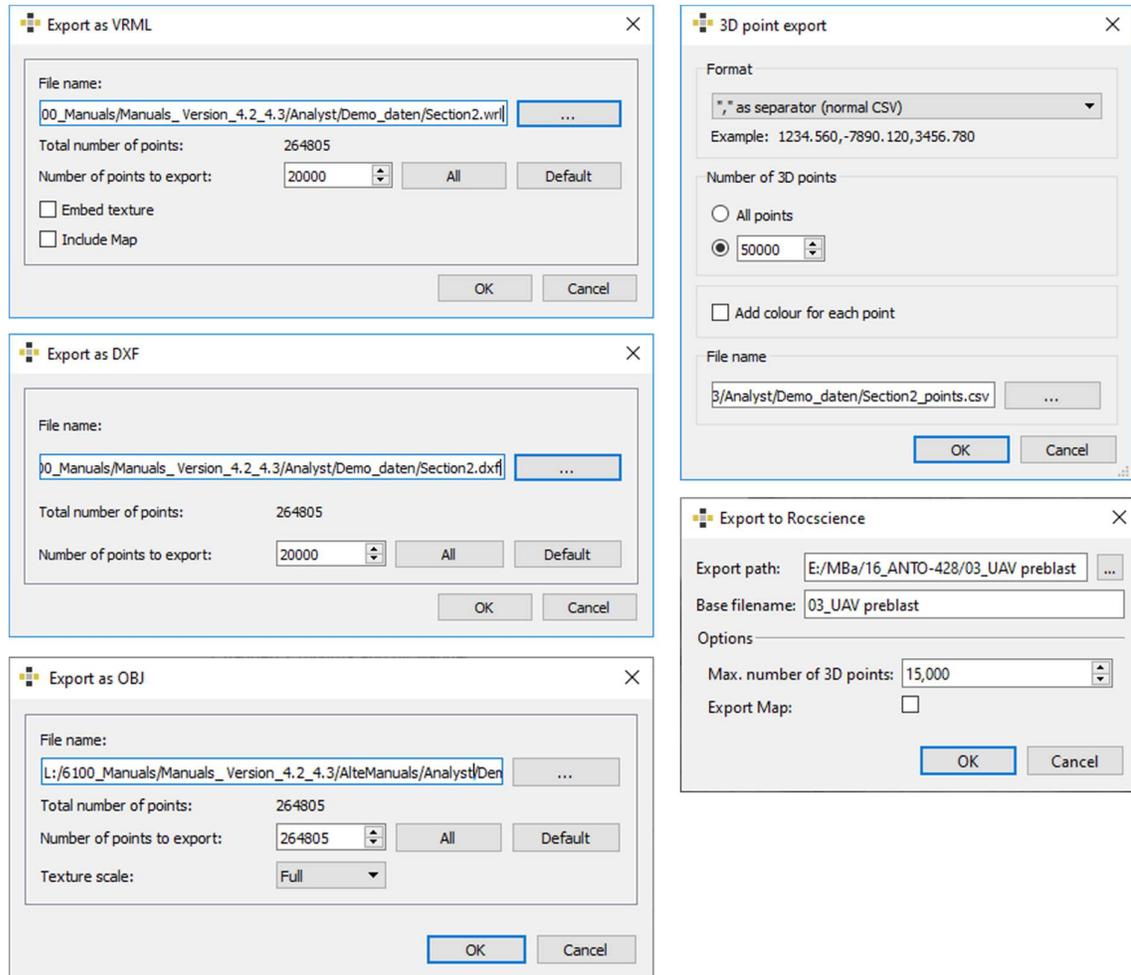
Figure 102: Dialogs for different file formats

Export Map

Following options are available:

- Export to Dips - *"Map| Export | Export Map as DXF.* Writes a "3gdps" file that allows for the exchange of structural-geologic mapping data between the *Analyst* and *Rocscience Dips* software.
Example:
SET_START
SetID,SetName,SetColour,meanDip,meanDipDirection,sphericalAperture,FisherConcentratio
degreeOfOrientation,coneOfConfidence,confidenceLevel,weightIndicator,meanSpacing,
standardDeviationSpacing,meanTraceLength,standardDeviationTraceLength
0,"unassigned",000000,-1.0,-1.0,-1.0,-1.0,-1.0,-1.0,-1.0,0,-1.0,-1.0,-1.0,-1.0
1,"StructureSet01",ff0000,26.5,283.5,0.84,4705.26,99.9,3.64,95.0,0,3.15,1.85,13.5,2.15
2,"My Set #2",0101df,21.4,200.72,32.72,3.42,70.78,0.0,95.0,0,-1.0,-1.0,-1.0,-1.0
SET_END
GRID_START

Dip,DipDirection,SetID,Colour,X(Easting),Y(Northing),Z(Elevation),Persistence
45.000,120.000,0,000000,100981.000,60345.000,1056.000,10.000
26.000,285.000,1,ff0000,100450.000,60120.000,1075.000,15.000
27.000,282.000,1,ff0000,100453.000,60125.000,1070.000,12.000
28.000,280.000,2,0101df,100451.000,60124.000,1065.000,13.000
45.000,160.000,2,58fa58,100481.000,60138.000,1045.000,-1.0
GRID_END

- DXF export - *"File | Export | Export Map as DXF"*: Writes a ".dxf" file of the geometry of selected *Annotation Elements* from the *Structure List* (Figure 103)

- VRML export - *"File | Export | Export Map as VRML":* Writes a ".vrml" 2.0 file containing data on the *Annotation Elements* from the *Structure List* (Figure 104)

- CSV export (Open Pit) - *"File | Export | Export Traces to Open Pit":* Writes a ".csv'" file of *Trace* parameters for Open Pit. Structure of Open Pit Simulator data file for *Trace* parameters:
 *"*Use?","Dip","deltaDip","DDir","DeltaDDir","Diam","Spacing","Phi","Coh","ObsTraces","Max Jnte","Domain"*
  12 numerical values

- CSV export:

  o *Scanline - "File | Export | Export Spacing Scanline Data as CSV":* Writes a ".csv" file of *Scanline* parameters (Figure 105)

  o Structural data: *"File | Export | Export Structural Geologic Data as CSV"*: Writes a ".csv" file of structural geologic data such as joint areas and traces (Figure 106). The export provides geometric information and reference to the measurement. The exported data can be configured by the user. The following options are available:
    - Unique Identifier
    - Name of the measurement
    - Structure set of the measurement
    - Coordinates – three columns (x, y, z or Easting, Northing, Height)
    - Orientation – two columns (dip direction, dip angle)
    - Length of the measurement (for *Traces*) | equivalent length of the measurement (for *Areas*)

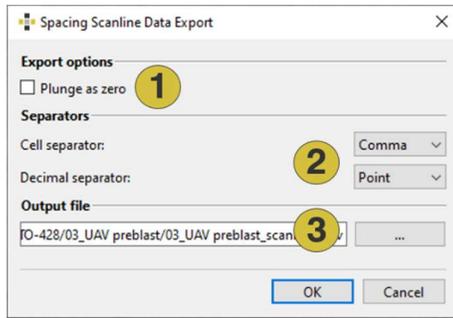 o Area partitioning data: *"Map | Export | Export Area Partitioning Data as CSV"* (analogue to Figure 106*)*
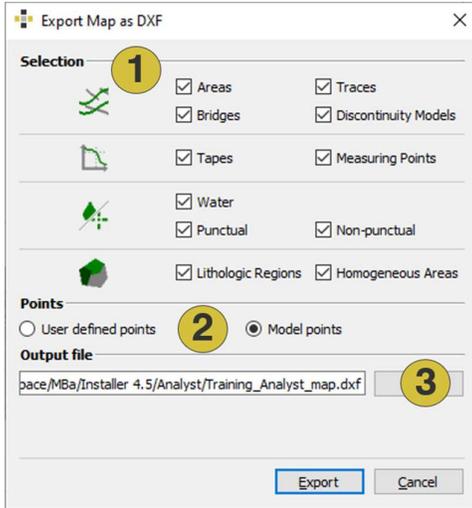
1 Exported annotation types

2 Model or user-defined points

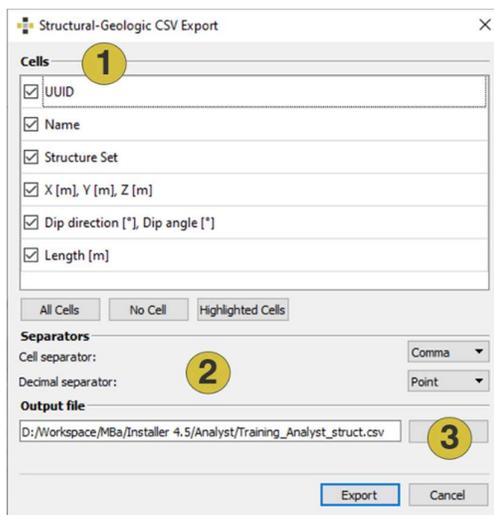**3** Folder and file name

Figure 103: Export map as ".dxf"
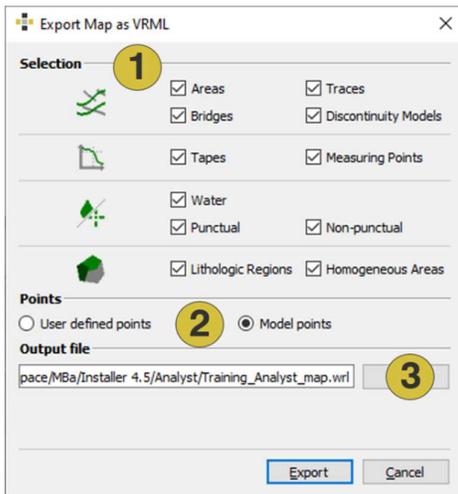
1 Exported annotation types

2 Model or user-defined points

3 Folder and file name

Figure 104: Export map as ".vrml"

1 Defines the plunge of the *Scanline* as zero

2 Type of separators

3 Folder and file name

Figure 105: Export spacing scanline data as ".csv"

1 Exported cells

2 Type of separator

3 Folder and name

Figure 106: Export structural geologic data as ".csv"

Export of Discontinuity Models

Following options are available:

- DXF Export: The shape of *Discontinuity Models* can be exported as ".dxf" file format (Figure 107). The export is available in the selected element´s context menu (*Discontinuity Model* and *Structure Set)* by selecting "*Export|Export Discontinuity Models as DXF".* The export is also available in the context menu of individual *Discontinuity Models* open by selecting the item in the *Structure Set* list and clicking the right mouse button. The export includes the shape of the discontinuity as a polygon. Following attributes *"Extended Data"* (metadata) can be added to the export:

- o Dip direction of *Trace* / Area

- o Dip angle of *Trace* / *Area*

- o Length of *Trace* / equivalent length of *Area*

Note:

Several *Discontinuity Models* are exported by multiple selection or selecting the corresponding *Structure Sets*. The user can select whether all measurements are exported into a single file, or each *Discontinuity Model* is exported in a separate file.

Note:

The third-party software needs to be capable of importing „*Extended Data"* for further processing of the attribute data.

The structure of the ".dxf" file for *"Extended data"* is as follows:

1001	*Code for registered application name for extended data*
GSM	*Application name*
1040	*Code for extended data floating point value*
178.33	*Dip direction of Trace / Area*
1040	*Code for extended data floating point value*
70.33	*Dip angle of Trace / Area*
1041	*Code for extended data distance value*
123.45	*Length of the Trace / equivalent length of the Area*

For further information please refer to: *AutoCAD 2012 - DXF Reference (https://images.autodesk.com/adsk/files/autocad_2012_pdf_dxf-reference_enu.pdf)*
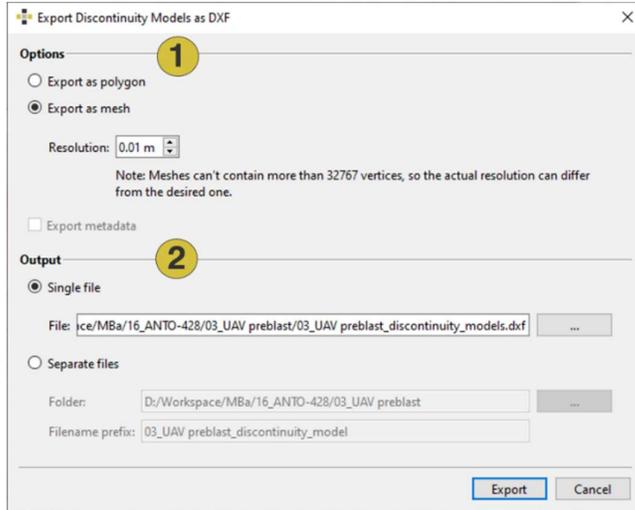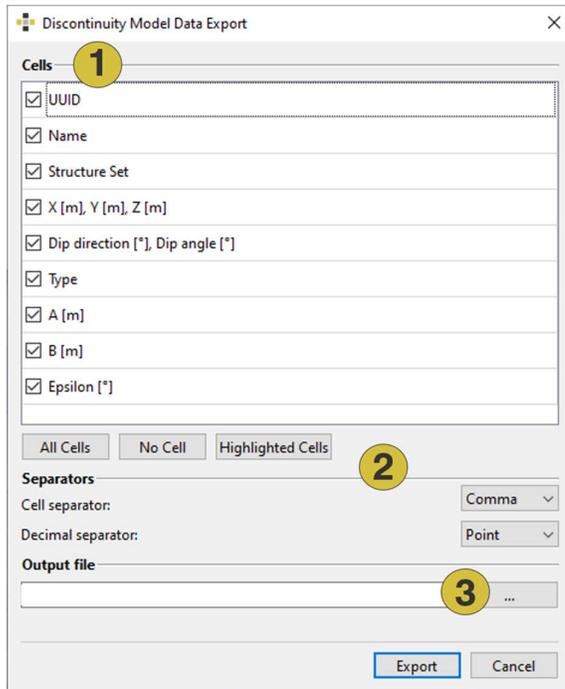
1   Options (polygon or mesh

2   Output options

Figure 107: Export Discontinuity Models as ".dxf"

CSV Export: *"File | Export | Export Discontinuity Models as CSV"*: Writes a ".csv" file of *Discontinuity Model* data (Figure 108). The export is also available in the context menu of individual *Discontinuity Models* open by selecting the item in the *Structure Set* list and clicking the right mouse button. The export provides geometric information and reference to the measurement. The exported data can be configured by the user. The following options are available:

> o   Unique Identifier
> o   Name of the measurement
> o   Structure set of the measurement
> o   Coordinates – three columns (x, y, z or Easting, Northing, Height)
> o   Orientation – two columns (dip direction, dip angle)
> o   Type (shape): circle, ellipse, rectangle
> o   Parameters (A, B, epsilon)

1   Exported cells

2   Type of separator

3   Folder and name

*Figure 108: Export Discontinuity Model data as ".csv"*

Note:

The ".dxf" and ".csv" export for *Discontinuity Models* is also available in the context menu of the individual models by selecting them in the *Structure Set* list.

Export of Discontinuity Surfaces

Discontinuity Surfaces can be exported as ".dxf" file format (Figure 109). The export is available in the selected element's context menu (*Discontinuity Surface* and *Structure Set)* by selecting "*Export | Export Discontinuity Surfces as DXF"*. The export is also available in the context menu of individual *Discontinuity Surface* opened by selecting the item in the *Structure Set* list and clicking the right mouse button as well as in the menu bar *"File | Export | Export Discontinuity Surface as DXF"*.

Note:

Several *Discontinuity Surfaces* are exported by multiple selection or selecting the corresponding *Structure Sets*. The user can select whether all measurements are exported into a single file, or each *Discontinuity Surface* is exported in a separate file.
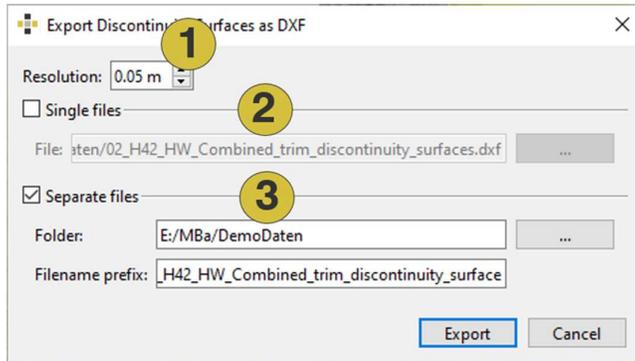
1 Mesh resolution

2 Export to single files

3 Export to separate files

Figure 109: Export Discontinuity Surface as ".dxf"

Generate 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 form the native of the monitor display. The export of the screenshot can be modified in the screenshot dialog (Figure 110), which opens subsequently after calling the command. Camera type, camera position and direction, and several settings options can be selected for the screenshot export.
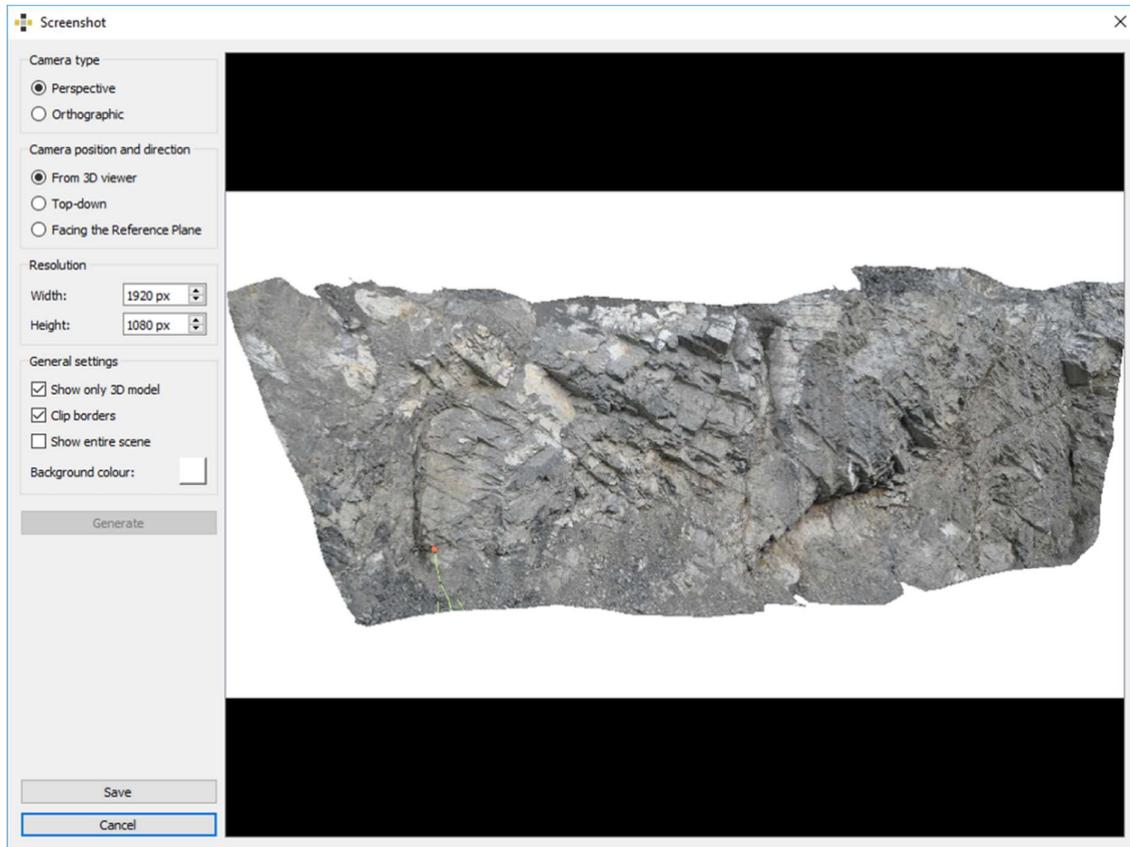
Figure 110: Export dialog for screenshot

10 Report

Analyst allows directly printing a report on the performed analysis using the commands *"File | Print Report"* (general printing), *"File | Export Report as PDF"* (".pdf" report) from the menu bar or by clicking the corresponding icon *"Print Report"* in the toolbar. Choosing one of these commands a dialog pops up containing two sheets (Figure 111). The *Project Information* sheet is used for providing project specific information such as report title, project, editor, company. It is also used to provide a company logo and defines whether a screenshot of the evaluated 3D model should be included or not. Figure 112 shows an exemplary printout of a 3D model evaluation including cover sheet and *Structure Set* information.
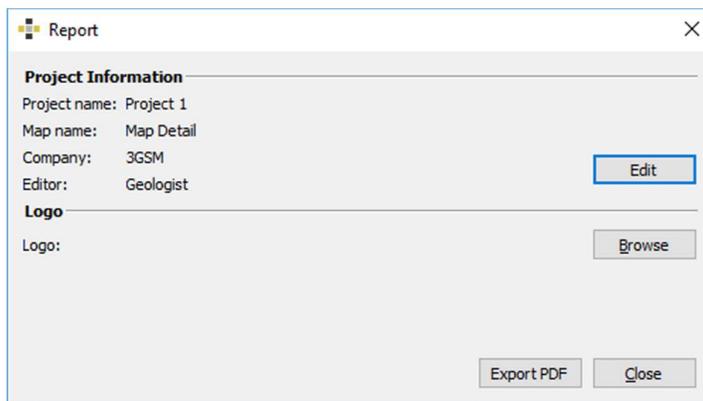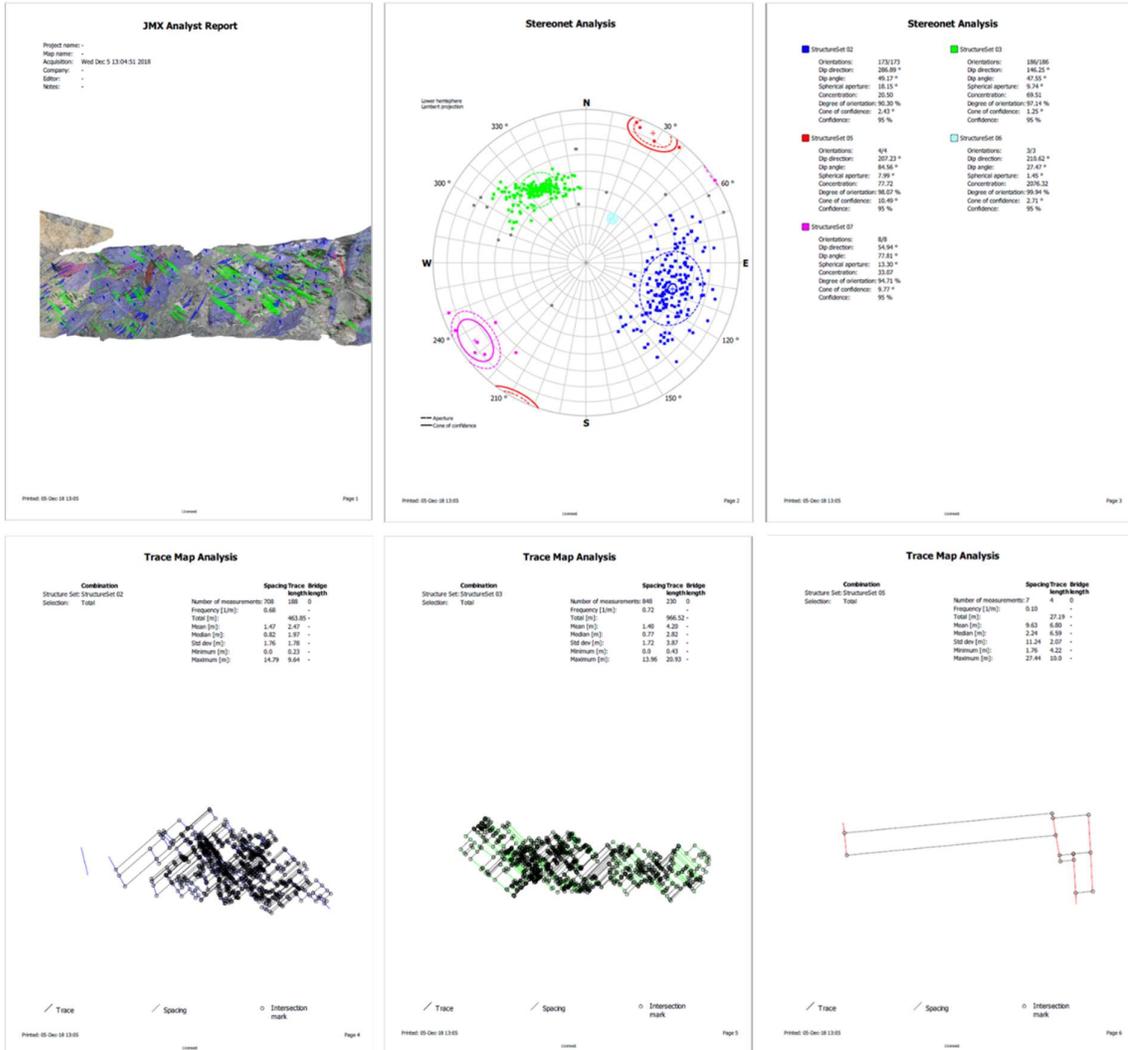

Figure 111: Report dialog

Figure 112: Example of Analyst report