User manual

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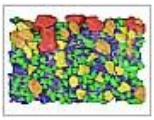
ShapeMetriX

BlastMetriX

BMX FragMetriX



User Manual
for Version 4.11
October 2024

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

CONTENTS

1 Introduction

The *BMX FragMetriX* is a software component for the fragmentation analysis of 3D models of muck piles and ripraps generated from drone imagery. It features the delineation of single particles on a 3D model by a combined 3D surface and image analysis, the sizing of particles based on the delineated surface patches, and the determination of the particle size distribution.

The *BMX FragMetriX* is tightly connected with *SMX MultiPhoto* which is a software component for the generation and scaling of 3D models from a large set of overlapping single images. Such 3D models are loaded directly into the *BMX FragMetriX*. The fragmentation analysis runs fully automatically and results are displayed in a particle size distribution plot and as individual delineated particles on the 3D model and on the corresponding ortho-photo. The *BMX FragMetriX* integrates seamlessly with *ShapeMetriX* and *BlastMetriX* and is a key component for the blast optimization cycle (see user manual *BlastMetriX Guideline* for further information).

This user manual addresses all topics related to the *BMX FragMetriX* i.e. installation, 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 system both, flexible enough for broad usage and sufficiently specific for your applications.

We wish you success with the *BMX FragMetriX.*

The Team of 3GSM

Graz, October 2024

2 General

The *BMX FragMetriX* is part of the *BlastMetriX package* and is not available as a stand-alone program. The installation takes place during the installation of *BlastMetriX* and is described in the corresponding user manuals.

Note:
The *BMX FragMetriX* is used under this name in *ShapeMetriX* and *BlastMetriX* packages, i.e. there is no dedicated *SMX FragMetriX*.

Attention:
The current version do not support 3D models (".jm3" files) generated with version older than *SMX MultiPhoto* v4.1. However, the current version reads fragmentation analysis ("frag" files) from former versions.

2.1 Functionality

General

The fragmentation analysis requires a scaled 3D model generated by the *SMX MultiPhoto*. The geometric information includes a 3D point cloud and the corresponding surface description (triangulated mesh). In addition, the 3D model provides visual information from images (real photographs) which are draped in the surface. Geometric analysis of the surface as well as image processing on the original pictures is used to determine the location, boundary and size of single particles. Results of fragmentation analysis are visualized by a user adjustable colour scheme in the viewer and in the *Particle Size Distribution (PSD)* plot.

Advice:
The determination of a muck pile's particle size distribution depends on the quality of the generated surface. Input photos need to show sufficient resolution and detail. The camera used for the detection of typical rock fragments in a muck pile should be better than 20 megapixels with a wide angle lens camera and recorded at an altitude of about 30 m or lower.

Attention:
The *BMX FragMetriX* requires 3D models with a high resolution topography and a high resolution texture. In order to achieve reliable results, 3D models have to be generated with the *High* setting in the *Dense Reconstruction Mode* in the *SMX MultiPhoto* (see corresponding user manual).

Particle computation settings

The *BMX FragMetriX* provides following particle computation modes, which has to be selected in the *Settings* pane (see Chapter 3.8):

- *Blast*: The mode is optimized for the analysis of uniformly distributed particles (fines to boulders). A typical use case is the analysis of blasted rocks.
- *Riprap*: The mode is optimized for the analysis of homogenously distributed particles (a certain grain fraction). A typical use case is analysis of embankment walls and ripraps.

Note:
The applied particle computation mode is saved by the software and is enabled per default when opened again.

File formats

The *BMX FragMetriX* deals with two file formats:

1. ".jm3" file (3D model) which contains the geometric information (3D point cloud and triangulated surface mesh) and the corresponding visual information (real photographs) of the surface. The ".jm3" file is generated by the *SMX MultiPhoto* and cannot be modified by the *BMX FragMetriX*.
2. ".frag" file which contains the defined surface for fragmentation analysis (see Chapter 4.1) and the corresponding results. The ".frag" file is generated by the *BMX FragMetriX.*

Attention:
Fragmentation analysis require 3D models (".jm3" files) which are generated with the same hardware key (identical Dongle ID) as used for executing the *BMX FragMetriX*.

2.2 Definitions

Following terms are used in the software:

Particles	Detected fragments with defined boundaries
Fines	Regions consisting of a multitude of fragments which cannot be detected as individual fragments. This is typically the case when the particle size is smaller than the resolution limit.
Borders	Outline borderline fragments that cross the analysis mask. Those fragments may not reflect their actual size, they are possibly cut by the mask.
Voids	*Voids* are regions which do not contribute to the fragmentation analysis results; they are excluded from the fragmentation analysis. Voids can **only** be assigned by the user.
MPS	*Median Point Spacing* is the median value of the 3D point spacing of the 3D model's point cloud
GSD	*Ground Sample Distance* is the size of ground captured by one pixel. This also refers to the geometric image resolution.
PSD	*Particle Size Distribution* is a plot of the relative (cumulative) amount of particles according to the particle size

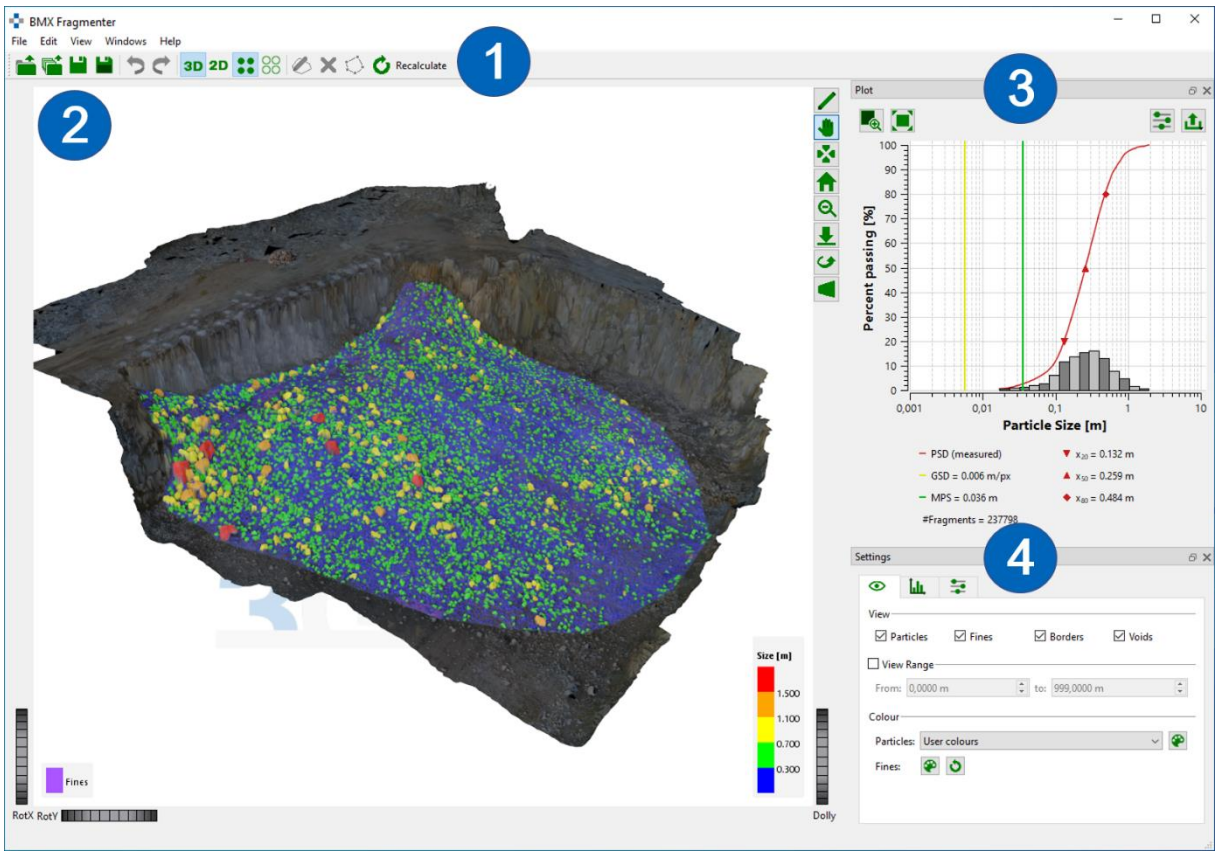
Note:
The minimum size of a detectable fragment depends on the 3D point spacing and the image resolution. Fragments smaller than this minimum size cannot be detected as individual particles.

3 User interface and features

3.1 User interface

The user interface of the *BMX FragMetriX* comprises the menu bar, the toolbar, the 2D/3D viewer, and three detachable panes i.e. *Data*, *Settings* and *Plot*. 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 is set to default by selecting the menu "*Windows | Reset Layout"*. The viewer and the panes are arranged to its original layout. The user can switch between the 2D and 3D viewer by clicking "2D" 2D or "3D" 3D icon in the toolbar.

Note:
The *Plot* and *Settings* pane are visible per default. The *Data* pane is requested from the menu "*Windows"*.



1 Menu bar and toolbar
2 3D viewer
3 *Settings* pane
4 *Data* pane

Figure 1: Interface of the BMX FragMetriX

3.2 Menu bar

The menu bar comprises five menus *File*, *Edit, View, Windows* and *Help*. The menu commands are accessible using the mouse cursor.

Menu File

Open 3D Model	Opens a 3D model (".jm3" file)
Load Analysis	Loads fragmentation analysis (".frag" file)
Save Analysis	Saves the fragmentation analysis to the current ".frag" file
Save Analysis as	Saves the fragmentation analysis to a new ".frag" file
Save 2D Image	Saves the current image as ".jpg" file
Exports	
Export Plot as CSV	Exports the plot to a ".csv" file
Export Plot PDF	Exports the plot to a ".pdf" file
Export Data as CSV	Exports the table data to a ".csv" file
Export Report as PDF	Writes a report directly to a ".pdf" file
Exit	Closes the *BMX FragMetriX*

Menu Edit

Undo	Revokes the previously executed commands step by step
Redo	Redoes the commands revoked by the *"Undo"* function step by step
Split Fragment	Splits a fragments into two parts
Split Fragment Automatically	Splits a fragment automatically into (several) parts
Merge Fragments	Merges two fragments
Merge Fragment Automatically	Merges several fragments automatically
Delete Fragment	Deletes a fragment
Edit Fragment	Enables to edit an individual fragment
Add Fragment	Adds a new fragment
Assign New Label	Assigns a label to a fragment
Edit Project Information	Defines a project name and adds notes to the current project

Menu View

Show 2D	Switches to the 2D viewer
Show 3D	Switches to the 3D viewer
Show Particle Colours	Enables/disables colouring of the fragments

Show Particle Boundary	Enables/disables the display of particle boundaries
Improve Contrast of Image	Enhances the contrast of the image in the viewer

Menu Windows

Reset Layout	Resets the layout
Data	Shows/hides the *Data* pane
Settings	Shows/hides the *Settings* pane
Plot	Shows/hides the *Plot* pane

Menu Help

User manual	Opens the user manual
Units	Displays the units used by the software
About FragMetriX	Displays version and release information of the software component

3.3 Toolbar

Open 3D Model

Opens a 3D model (“.jm3” file)

Load Analysis

Loads fragmentation analysis (“.frag” file)

Save Analysis

Saves the fragmentation analysis to the current “.frag” file

Save Analysis as

Saves the fragmentation analysis to a new “.frag” file

Undo

Revokes the previously executed commands step by step

Redo

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

3D View

Switches to the 3D viewer

2D View

Switches to the 2D viewer

Show Particle Colours

Enables/disables colouring of the fragments

Show Particle Boundary

Enables/disables the display of particle boundaries

Draw Mask

Reduces the analysis area by drawing an polygon

Clear

Clears the analysis mask

Edit Mode

Opens the toolbar for editing fragments

Recalculate

Starts fragmentation analysis

Toolbar: Edit Mode

Split Fragment

Splits a fragments into two parts

Split Fragment Automatically

Splits a fragment automatically into (several) parts

Merge Fragments

Merges two fragments

Merge Fragment Automatically

Merges several fragments automatically

Delete Fragment

Deletes a fragment

Edit Fragment

Enables to edit the boundary of individual fragments

Add Fragment

Adds a new fragment

Pull down menu: Assign New Label

Assigns labels (*Particles*, *Fines*, *Borders* or *Voids) to fragments*

3.4 Viewers

2D Viewer

The viewer window comprises two scroll bars and five buttons supporting the image display (Figure 2):

Window fit

Fits the size of the image to the size of the viewer

Zoom in

Zooms into the photo

Zoom out

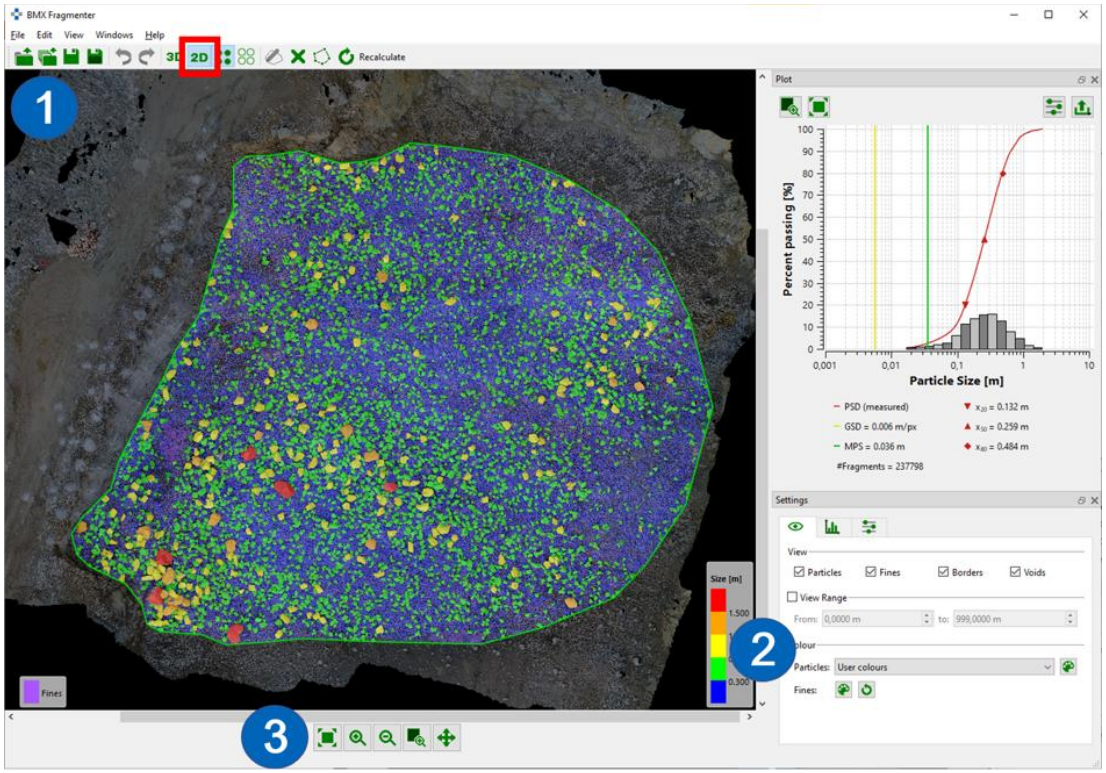
Zooms out of the photo

Zoom to region

Enables to zoom in and out by using the computer mouse

Move

Enables mouse navigation



1 Viewer window
2 Scroll bar
3 Functions

Figure 2: Viewer window of the stereo viewer

Hint:
Mouse navigation: Zooming can also be done using the mouse wheel after clicking the *"Move"* button.

Hint:
Panning is performed with the horizontal and vertical scroll bars at the bottom and the right hand side of the viewer window or by keeping the middle mouse button pressed.

Individual fragments are selected in the 2D viewer by clicking the left mouse button on the item. The fragment is highlighted (red boundary) in the viewer as well as in the in the *Data* pane (see Chapter 3.9). Multiple fragments are selected by enclosing the fragments by dragging the cursor while keeping the left mouse button pressed. After releasing the mouse button selected fragments are highlighted. See Figure 3.

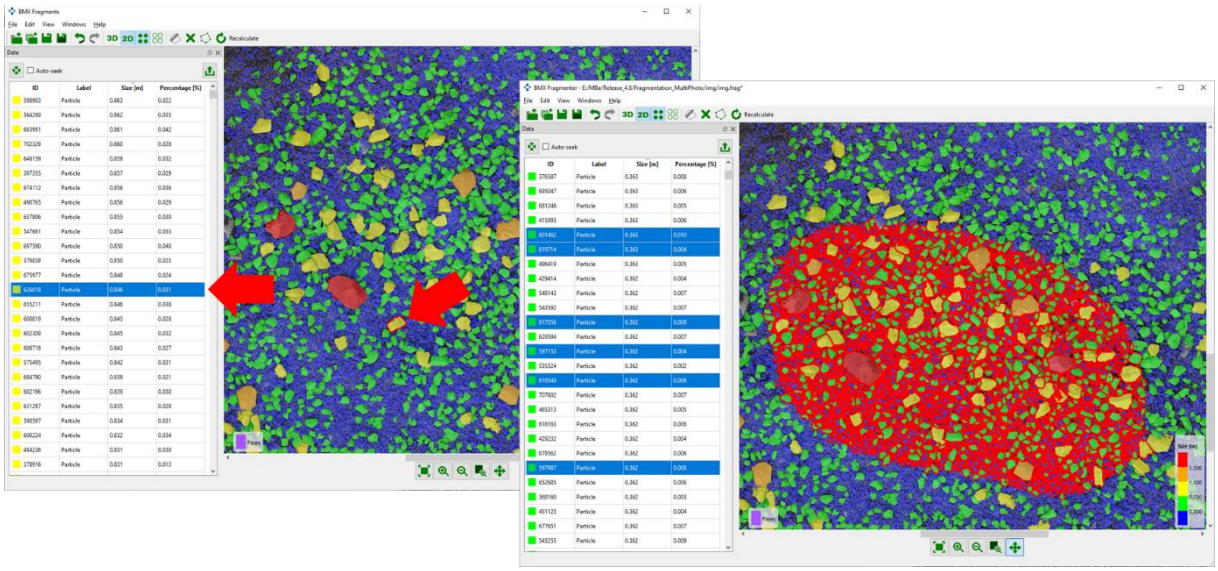


Figure 3: Selection of an individual fragment (left) and multiple fragments (right) in the 2D viewer and in the Data pane

Note:
An information insert appears when moving the mouse cursor on a detected fragment (Figure 4). The insert shows the fragment ID, the particle size, its relative percentage and assignment (label).

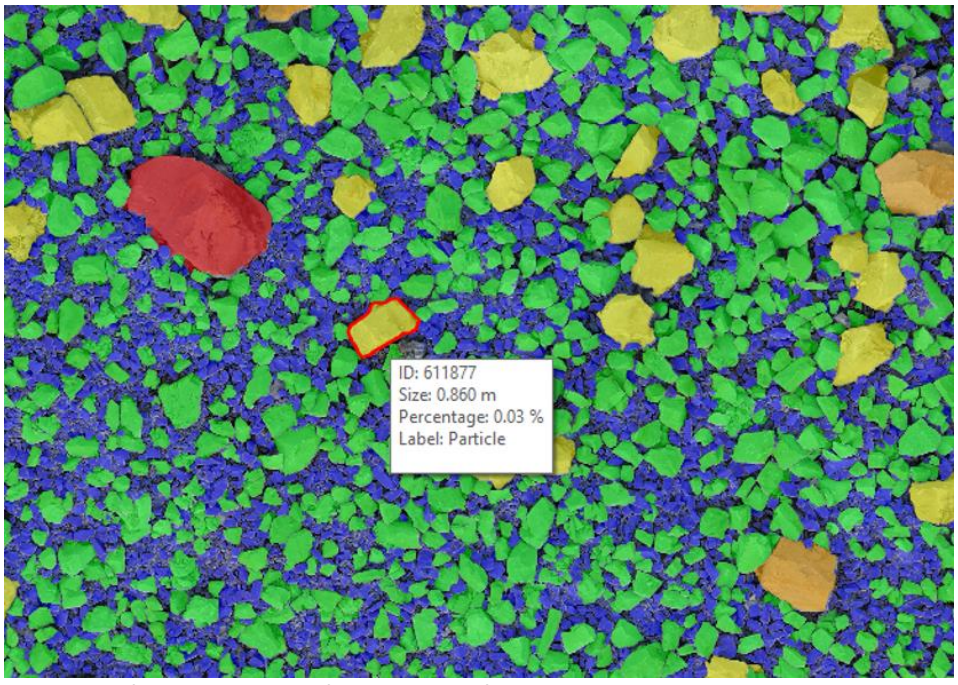
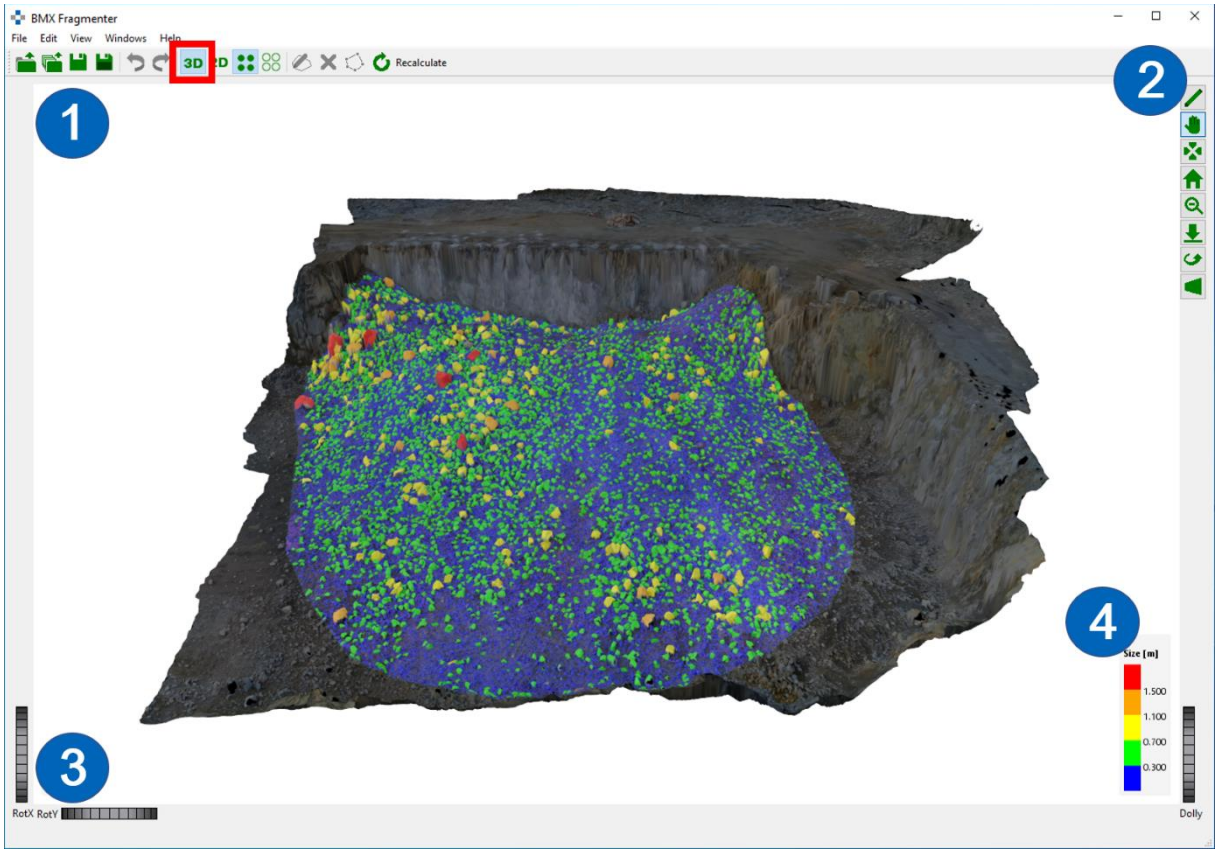


Figure 4: Information insert of an individual fragment

3D Viewer

The 3D model with the corresponding fragmentation results (colour coded overlay) are displayed in the 3D viewer by clicking the "*3D Fragmentation*" 3D icon in the toolbar (Figure 5). The colour overlay insert (legend) is located at the bottom right corner of the 3D viewer. It comprises a user adjustable colour scale. Each colour within corresponds to a certain span.

Note:
The 3D viewer serves for visualization of fragmentation results on the 3D model only. Localization of individual fragments (see Chapter 3.9) and editing (*Edit Mode* in the toolbar, see Chapter 4.3) is done in the 2D viewer.



1 Viewer window
2 Navigation bar
3 Thumb wheels
4 Colour legend

Figure 5: Viewer window of the 3D viewer

3.5 Navigation bar

Hint:
The *BMX FragMetriX* toggles between the *Edit* and *Navigate* mode by pressing the "*Esc*" key.

Edit

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

Navigate

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

Seek to a Selected Point

Zooms towards the selected location on the 3D model

Move to Home Position

Sets the viewer to its initial position

Zoom out / Zoom in

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

Top Down View

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

Auto Rotate (fixed or view)

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

Toggle Perspective/Parallel Projection

Toggles between perspective and parallel projection

Thumb wheels

The thumb wheels are used for rotation and zooming

3.6 Mouse and keyboard navigation

Mouse navigation

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

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

Keyboard navigation

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

Scrolling mechanism

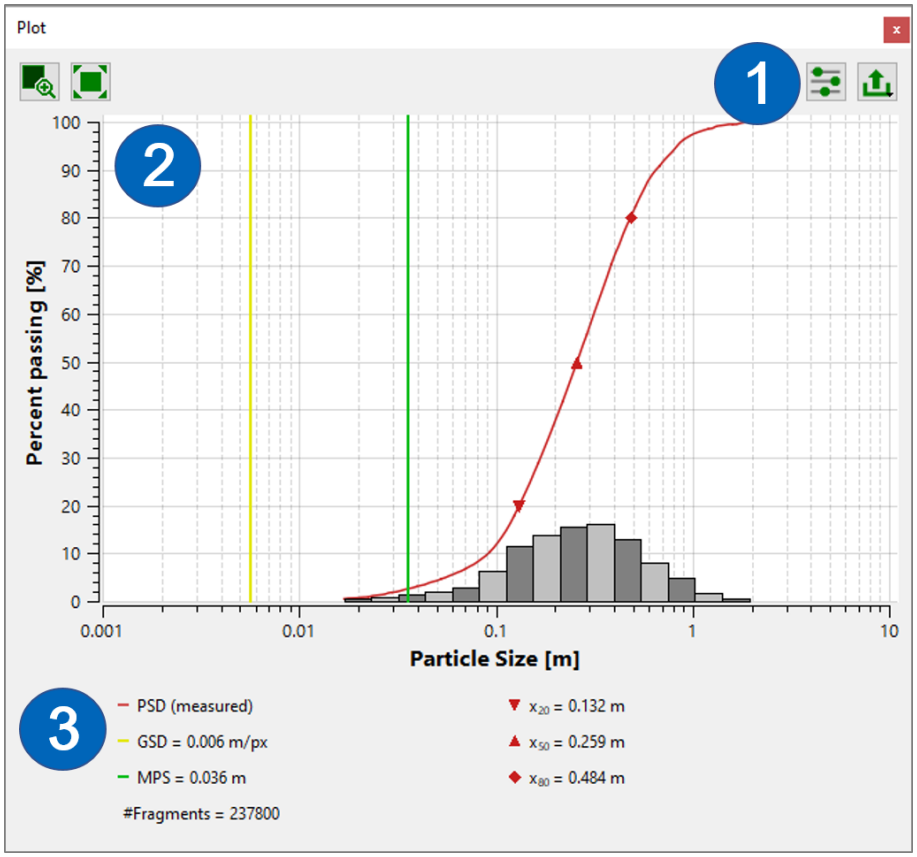
The scrolling mechanism is a fast and easy way to change parameter values with the wheel of the computer mouse. Move the mouse cursor over the input field of the corresponding parameter and turn the mouse wheel. The entered numbers are highlighted and increase or decrease according to the spin of the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

3.7 Plot pane

The *Plot* pane (Figure 6) shows the *Particle Size Distribution (PSD)* of the detected fragments by plotting the (cumulative) relative amount of particles (percent passing) according to the particle size. By default following parameters are given:

- *Median Point Spacing (MPS*) of the current 3D model
- *Ground Sample Distance (GSD)* in the images of the current 3D model
- x_20 reveals the diameter of particles for which 20 percent of the particles are finer and 80 particles are coarser
- *x_50* reveals the diameter of particles for which 50 percent of the particles are finer and 50 particles are coarser

- *x_80* reveals the diameter of particles for which 80 percent of the particles are finer and 20 particles are coarser
- *# Fragments:* Number of active fragments (*Particles* and *Borders;* see Chapter 3.8)



1 Tool bar
2 *Particle Size Distribution Plot*
3 Info and results
Figure 6: Plot pane

Tool bar

Zoom to Rectangle

Activates a zoom function. The plot is zoomed to the size of a rectangle drawn by holding the left mouse button pressed.

Reset View

Resets the view of the plot according to the configuration of the plot

Plot Configuration

	Opens the *Configuration* dialog

Exports

Save as Image	Saves the current image as ".jpg" file
Copy Image to Clipboard	Copies the image to clipboard
Export Plot as CSV	Exports the plot to a ".csv" file
Export Plot as PDF	Export the plot to a ".pdf" file

The *Plot Configuration* (Figure 7) dialog is opened by clicking the "*Plot Configuration*" icon. The grid can be adapted by selecting *"None"*, *"Major"* and "*Major and Minor*" from the pull down menu *General/Draw Grid*. The axes can be adapted individually by selecting "*Custom range*" from the pull down menu and entering the desired range in the corresponding fields, *X-Bottom* (particle size) and *Y-Left* (percent passing).

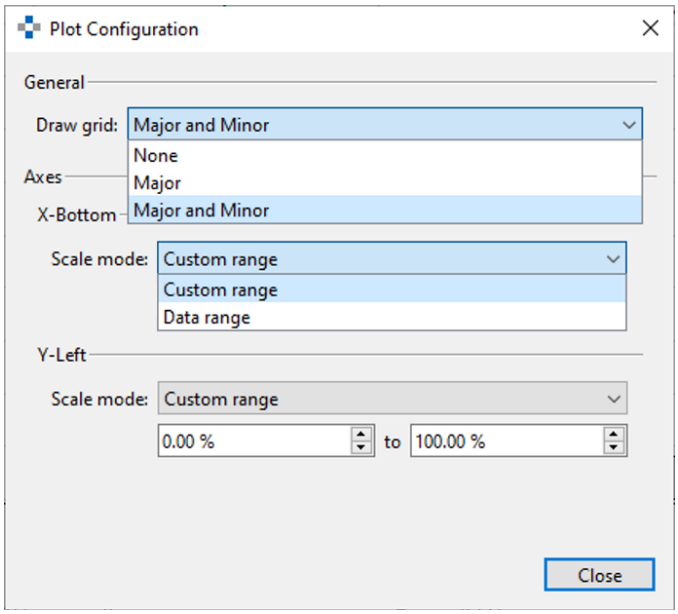


Figure 7: Plot configurations

3.8 Settings pane

The *Settings* pane comprises the dock bar and three tabs, i.e. *View Settings*, *Plot Settings* and *Computation* tab, which can be switched. The features of the provide tabs are described in the following.

View Settings

- View

- Particles — Enables/disables the visibility of *Particles*
- Fines — Enables/disables the visibility of *Fines*
- Borders — Enables/disables the visibility of *Borders (Particles)*
- Voids — Enables/disables the visibility of *Voids*

- View range — Limits the lower and upper size of active particles
- Colours
  - Particles — Definition of the colour scheme of detected particles by user selection from the pull-down menu
  - Fines — Opens a dialog for selecting a customized colour for *Fines*

Note:
Changes in the *View Settings* are affecting the 2D viewer as well as the 3D viewer.

Colour schemes

The *BMX FragMetriX* supports a variety of predefined colour schemes. In addition, the software enables a user defined colouring of particles by selecting "*User Colours*" in the pull-down menu. The colour and range is defined in the *Edit User Colours* dialog (Figure 8) opened by clicking the "*Select Particle Colours*" icon next to the pull down menu.

The user can change the colour ranges by entering the lower (*From*) and upper limits (*To*) of particle sizes in the fields corresponding to a single colour. The colour is changes by clicking on the coloured field and choose the desired colour in the *"Select Colour"* dialog (Figure 9).

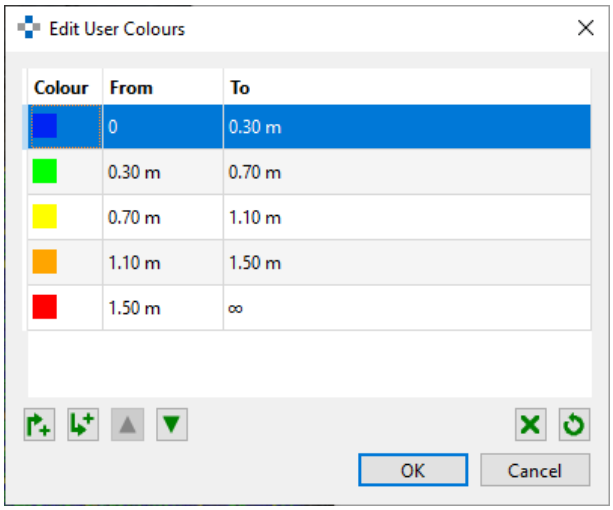


Figure 8: Edit user colours

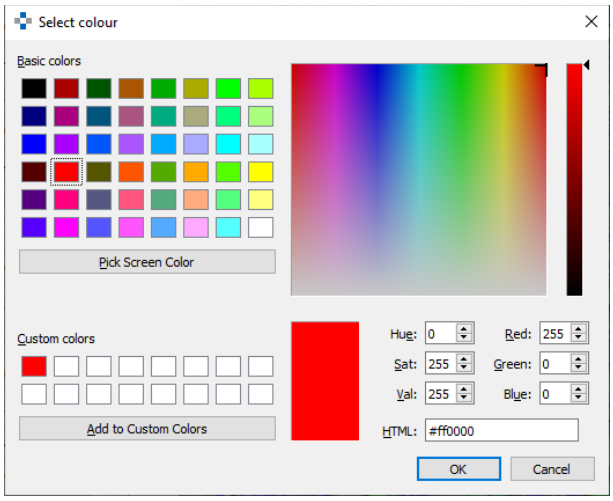


Figure 9: Select Colour dialog

Additional features are provided to adapt the colour scheme:

Insert Row Above Selection

Inserts a colour class above the selected class

Insert Row Below Selection

Inserts a colour class below the selected class

Move Selection Up

Move the selected colour class up

Move Selection Down

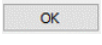
Moves the selected colour class down

Remove Selection

Deletes the selected colour class

Reset to Defaults

Resets the colour scheme to default colours and values

The customized scheme is applied by clicking the “Ok”  button.

The colour of *Fines* is adapted by clicking the "*Select Fine Colour*" icon. The *"Select Colour"* dialog (see Figure 9) opens and the user can select the colour by mouse interaction. The colour is set to default again by clicking the "*Reset Fine Colour to Default*" icon .

Plot Settings

- Histogram
  - Bins — Defines the class division (bins) of the histogram in the *Particle Size Distribution Plot*
  - *Fragmentation model* — Adds a distribution function to the plot (see below)
  - *User defined % passing* Defines a user defined value for percentage passing
- *View*
  - *MPS* — Enables/disables the display of the *MPS* value as green vertical line in the *Particle Size Distribution Plot*
  - *GSD* — Enables/disables the display of the *GSD* value as yellow vertical line in the *Particle Size Distribution Plot*
  - *User defined % passing* — Enables/disables the display of the particle size at a user defined percentage of particles (x_{user}) in the *Particle Size Distribution Plot*

The following best-fit distribution function are available in the software:

- Rosin-Rammler
- Swebrec
- Swebrec extended

Given plot parameters for the functions are:

- *x_50* — median particle size for the best fit distribution function
- *N, N_eq:* — degrees of uniformity
- *a, b, c:* — curve shape parameters

For further information refer to: F. Ochterlony (2005). The Swebrec © function: Linking fragmentation by blasting and crushing. Trans. Inst. Min. Metall., Section A: Mining Technology, Vol. 114; A29 – A44

Computation settings

- Size unit — Available units are millimetre [mm], meter [m], inch [in], internationalfoot [ft] and US survey foot [ft]
- Preset

- *Blast* Mode for general particle size distributions
- *Riprap* Mode for homogenous particle size distributions

- Include
  - Fines Includes/excludes *Fines* from the analysis
  - Borders Includes/excludes *Borders* from the analysis

3.9 Data pane

The *Data* pane (Figure 10) lists the detected fragments in a table. A fragment selected in the list is also highlighted in the viewer by a red coloured boundary (see Figure 3). The fragment is located by clicking the *"Seek to Fragment"* icon. By enabling the checkbox Auto-seek *"Auto-seek",* fragments are automatically located when selecting them in the table. The data is exported to ".csv" by clicking *"Export Data CSV"* icon or using "*File | Export Data as CSV"* from the menu bar. Please refer to Chapter 5.2 for further information.

Note:
The features *"Seek to Fragment"* and *"Auto-seek"* are only active in the 2D viewer.

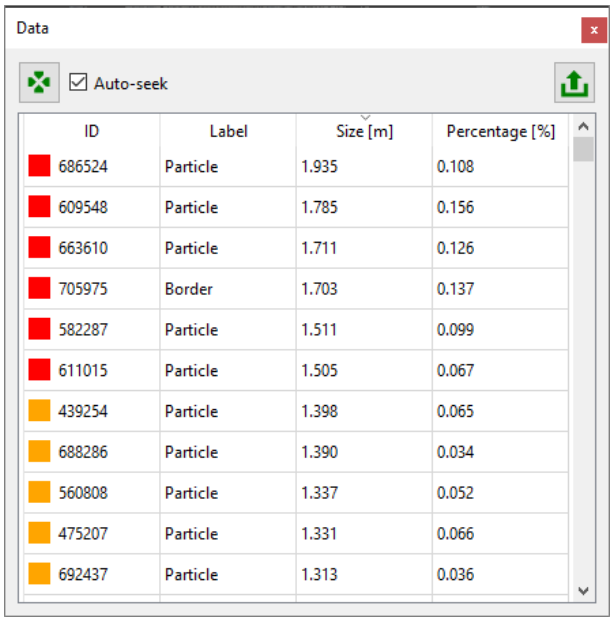


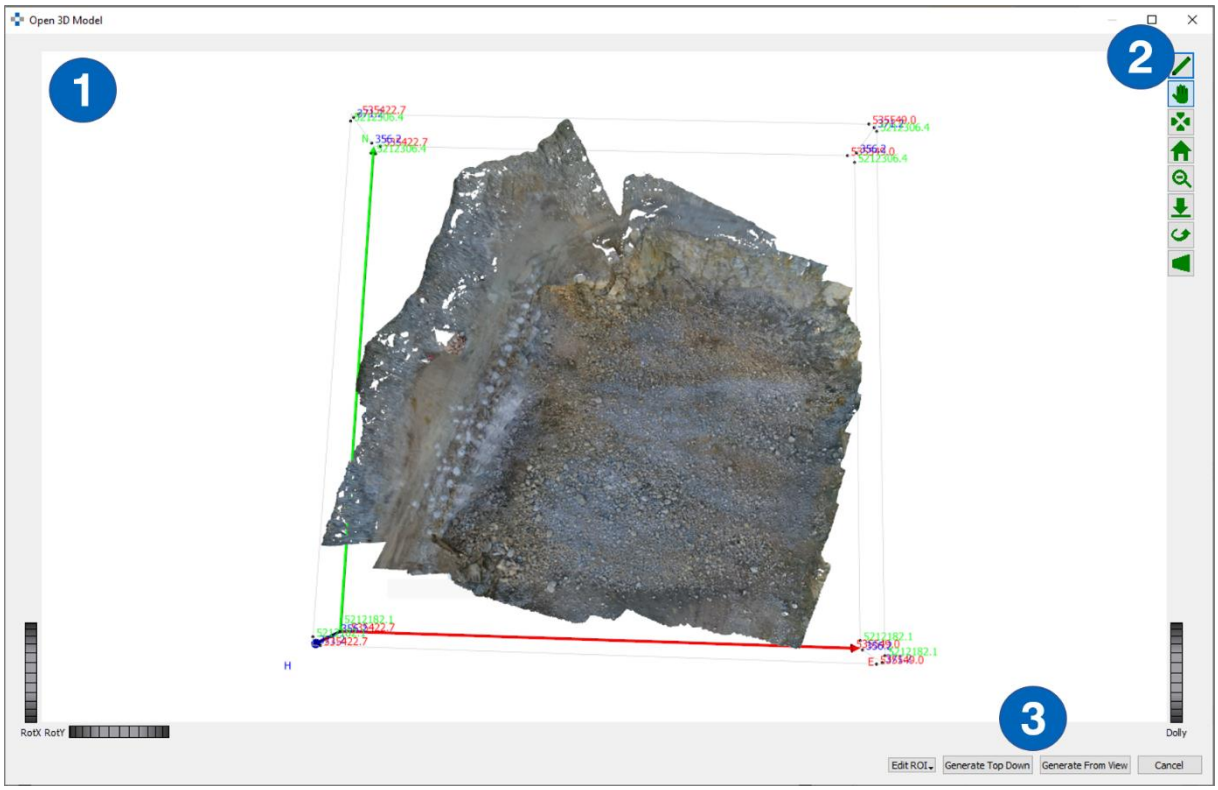
Figure 10: Data pane

4 Operations

4.1 Definition of the surface

The BMX FragMetriX requires the generation of a dedicated surface for the fragmentation analysis. The generation of the surface is defined by the camera view vertically downwards ("*Generate Top Down*") or from a user defined view, which is currently visible in the 3D viewer ("*Generate from View*"). In addition, the surface to analyse can be limited by defining a so called *Region of Interest (ROI)*.

1. Open a 3D model by clicking *"File | Open 3D Model"* in the menu bar and the dialog *"Open 3D model"* (Figure 11) occurs and inspect the 3D model in the viewer.



1 3D viewer
2 Navigation bar
3 Features

Figure 11: Dialog for defining the surface for fragmentation analysis

2. *Optional* – limit the generation of the surface to certain area by defining a region of interest (ROI). See description below.

3. Generate the surface by using one of the following options:

    - *Top Down:* Click the *"Generate Top Down"* Generate Top Down button to generate the surface for fragmentation analysis from the camera view (top down). This will be sufficient for most of the muck piles in quarry operations surveyed by aerial imagery with Nadir flights.
    - *From View:* Align the 3D model in the 3D viewer such that you have an optimized view on the fragments. Click the *"Generate From View"* Generate From View button to generate the surface for fragmentation analysis from the current view. This will be the preferred method if the muck pile has a significant slope and it was surveyed towards this particular direction (e.g. from the ground or with inclined cameras).

Region of Interest (optional)

Limit the generation of the surface to a specific area as follows (see Figure 12):

1. Click the *"Edit ROI"* Edit ROI button and select *"Append Point"* in the pull-down menu
2. Mark the border line of the *Region of Interest* 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).
3. Draw a polygon which encloses the *ROI* by clicking the left mouse button
4. Confirm the polygon by pressing the *"Enter"* key or the middle mouse button
5. Edit the *ROI* by using the commands *"Insert Point", "Delete Point"* and *"Move Point"* from the pull-down menu if necessary
6. Delete the *ROI* by choosing *"Delete ROI"* from the pull-down menu

Note:
Make sure that the "*Edit Mode*" (navigation bar) is active when editing the *ROI*.

Note:
The *ROI* is used for trimming a 3D model. To confine the fragmentation analysis to a specific region use the analysis mask (see Chapter 4.2.).

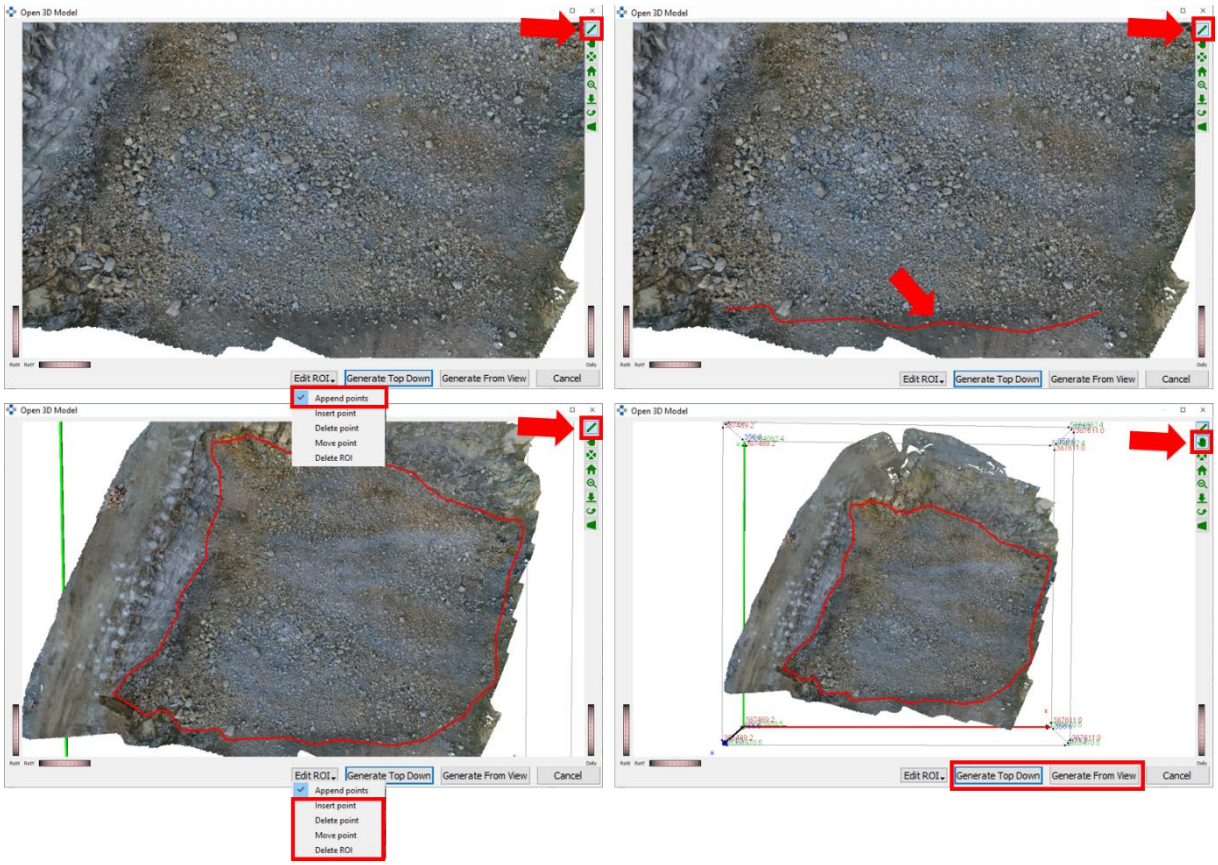


Figure 12: Top left: Choose "Append Points" from the pull-down menu "Edit ROI". Top right: Draw the polygon by using the computer mouse. Bottom left: Edit polygon with the features provide in the pull-down menu "Edit ROI". Bottom right: Align the 3D model in the viewer and click "Generate from View" or click "Generate Top Down" to generate the surface for fragmentation analysis.

4.2 Run fragmentation analysis

1. Ensure that the suitable computation mode is active; i.e. *Blast* or *Riprap* (see Chapter 2.1 and Chapter 3.8).

2. *Optional* – confine the fragmentation analysis to a specific area by drawing a mask. See description below.

3. Run the fragmentation analysis by clicking the *"Recalculate"* button in the tool bar. The appearing dialog shows the current status of processing (Figure 13). The processing time depends on the size of the 3D model and the computational power. Results are displayed in the 3D viewer (colour overlay of detected fragments) and in the *Plot* pane (*Particle Size Distribution Plot*). See Figure 14.

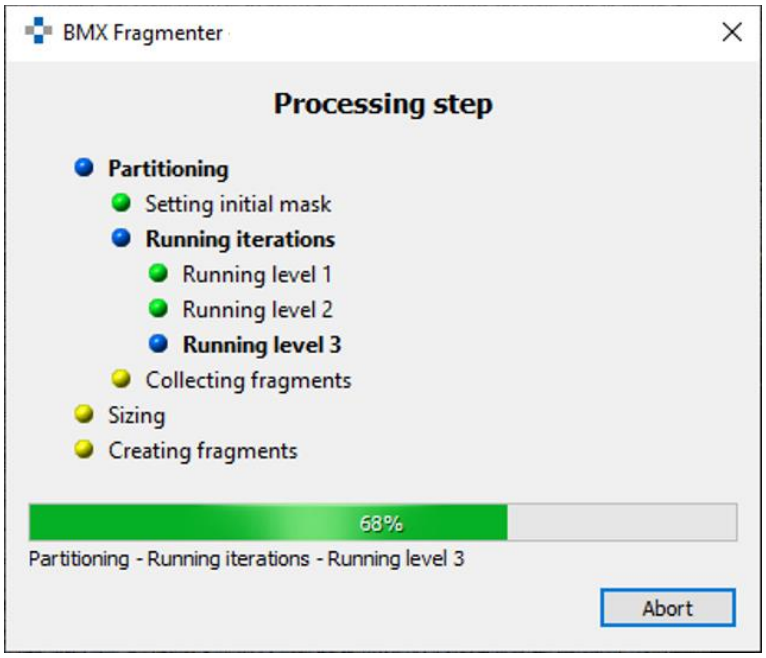
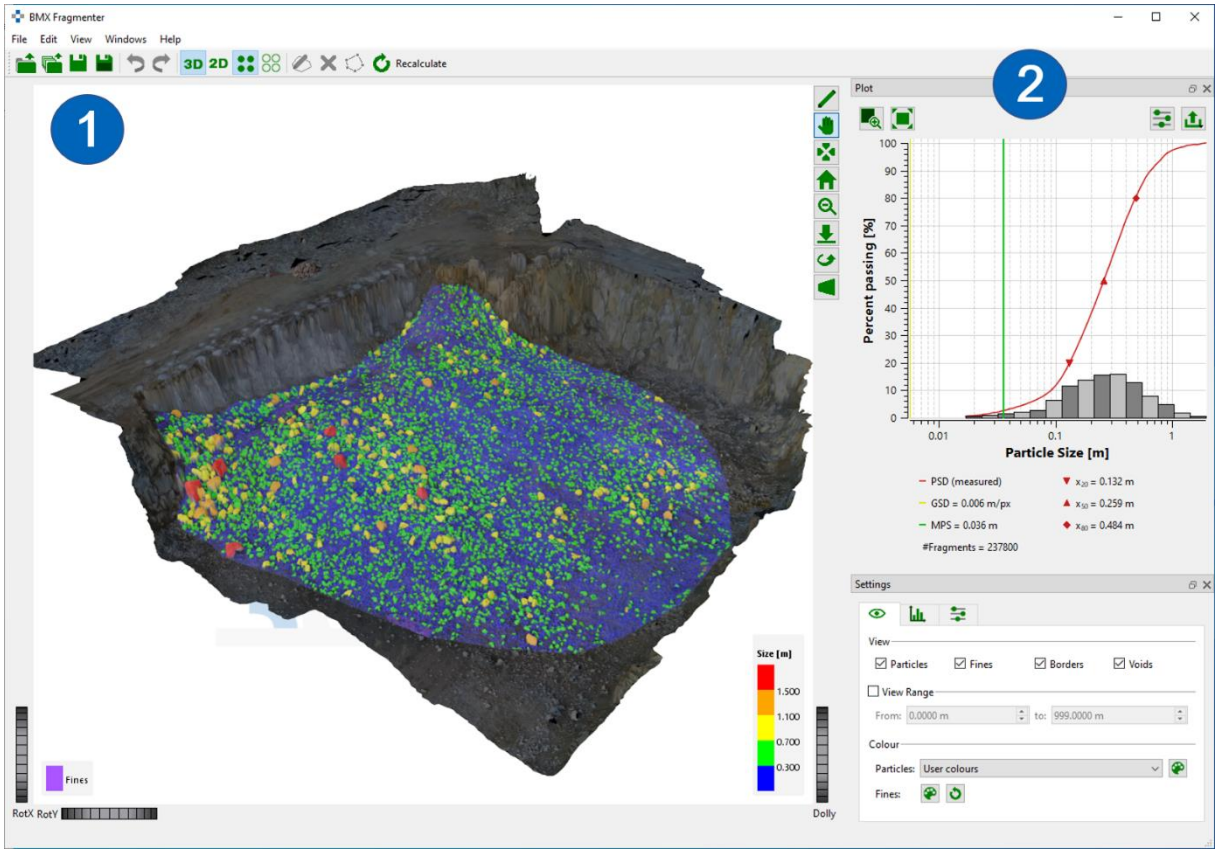


Figure 13: Processing



1 3D viewer with detected fragments
2 *Particle Size Distribution Plot*

Figure 14: Results of fragmentation analysis

4. Adapt the results by using the features in the *Settings* pane (see Chapter 3.8). The 3D/2D viewers, the *Particle Size Distribution Plot* and the corresponding data in the *Data* pane are updated automatically

Analysis mask (optional)

The fragmentation analysis is limited to a specific area by drawing a mask (see Figure 15) by following procedure:

1. Ensure that the 2D viewer is active
2. Click the *"Draw Mask"* button in the toolbar
3. Mark the border line of the mask on the image by clicking the left mouse button. A polygonal yellow line grows instantaneously. Undo the last action by pressing the right mouse button (multiple uses possible).
4. Confirm the polygon by pressing the *"Enter"* key or the middle mouse button
5. Run the fragmentation analysis by clicking the *"Recalculate"* button in the tool bar

Note:
Drawing an analysis mask is supported in the 2D viewer only.

Note:
The mask (together with detected particles) is deleted by clicking the *"Clear"* icon in the toolbar.

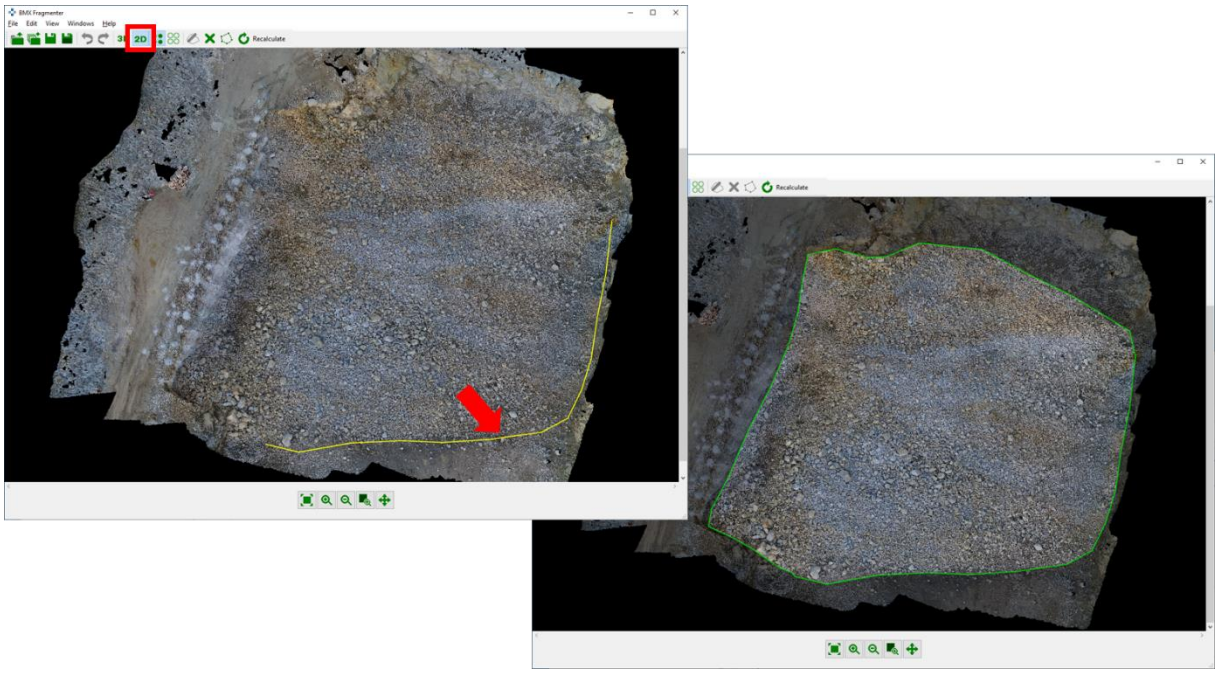


Figure 15: Left: Draw a polygon (yellow line) by using the computer mouse. Right: After conformation the analysis area is highlighted (green border) in the viewer.

4.3 Editing of fragments

The *BMX FragMetriX* allows editing fragments. Individual fragments are edited by using the features of the *"Edit Mode"* provided in the toolbar (see Chapter 3.3). Enter the *"Edit Mode"* by clicking the corresponding icon in the toolbar.

Note:
Editing of fragments is supported in the 2D viewer only (see Chapter 2.1).

The *"Edit Mode" provides the following tools:*

- Splitting of a fragment
- Merging of fragments
- Editing the boundary of a fragment
- Deleting fragments
- Adding fragments
- Changing the label of a fragment

Splitting of fragments

There are two different splitting features provided:

1. *"Split Fragment"* splits a fragments into two particles. Activate in the corresponding icon in the toolbar and click on two different positions on the fragment (see Figure 16). *"Split Fragment"* considers the properties of the texture in the fragment's texture patch. The split will be applied along the most prominent texture features of the fragment's patch between the two clicked points. If a particular split line shall be preferred, it is recommended to click close to this split line on either side.

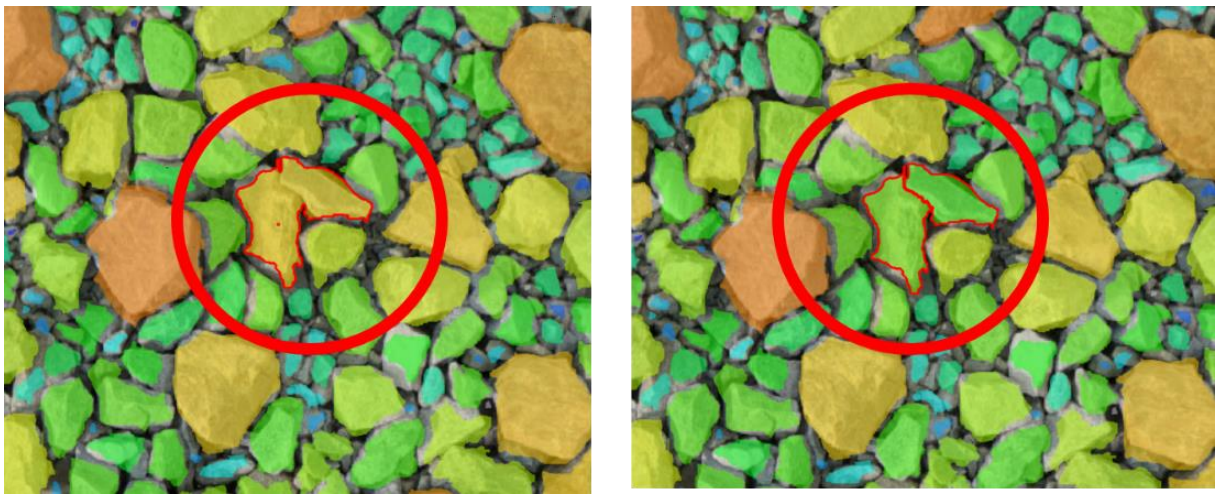


Figure 16: Splitting a fragment into two fragments

2. *"Split Fragment Automatically"* automatically splits a fragment into several fragments. Activate the corresponding icon in the toolbar and click somewhere within the fragment to split (Figure 17). *"Split Fragment Automatically"* considers the properties of the texture in the fragment's texture patch and is applied subsequently to achieve splitting into smaller fragments.

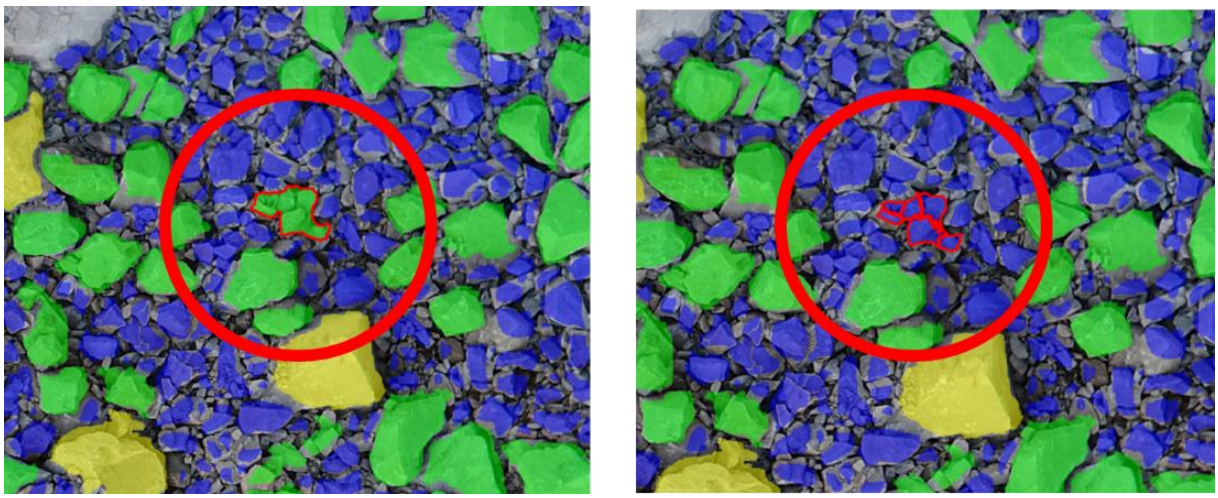


Figure 17: Automatically splitting a fragment. In this example the original fragment is spit into six fragments with the automatic mode

Merging of fragments

There are two different merging features provided:

1. *"Merge Fragments"* merges two fragments into one. Activate the corresponding icon in the toolbar and click on the two fragments to merge (Figure 18).

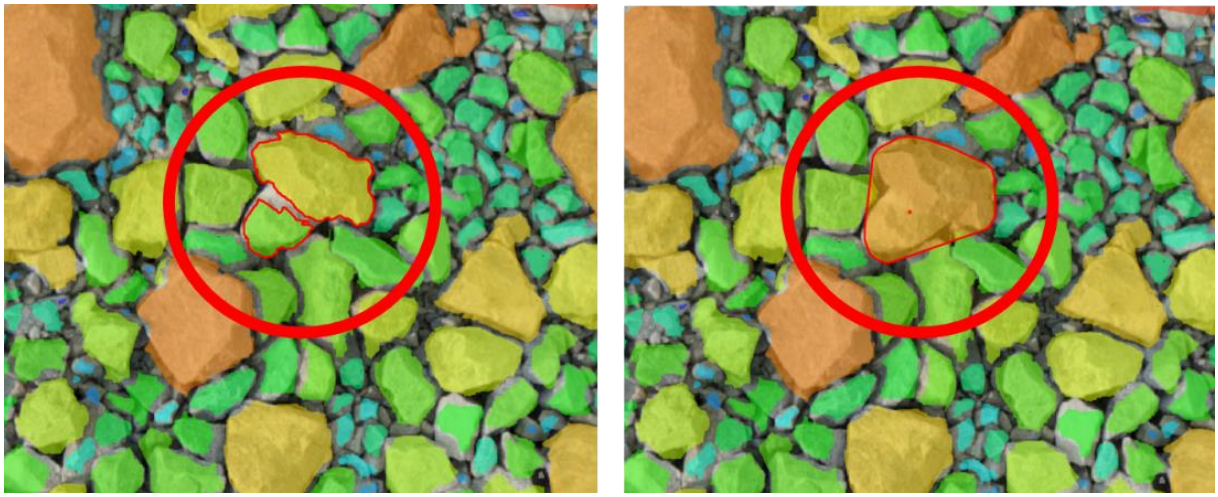


Figure 18: Merging of two individual fragments

2. *"Merge Fragments Automatically"* merges several fragments into one. Activate the corresponding icon in the toolbar and select the fragments to merge by a polygon using the computer mouse (Figure 18). Confirm the selection by clicking the middle mouse button or the "*Enter*" key.

Note:
Fragments are selected if they are enclosed by the polygon or if they cross the border of the polygon.

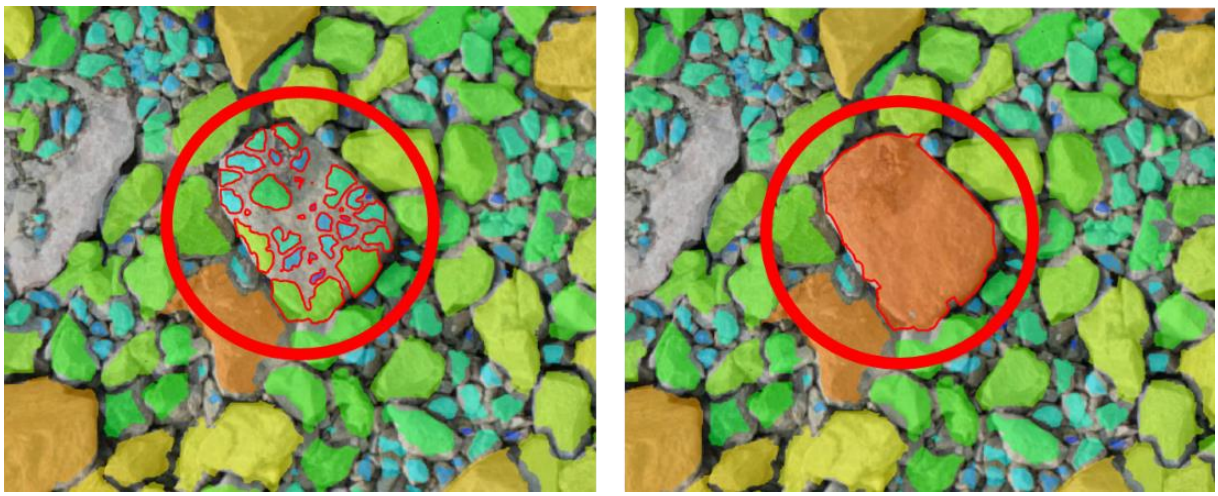


Figure 19: Merging of several fragments automatically into one fragment

Delete fragments

Activate the icon *"Delete Fragment"* in the toolbar. Single fragments are deleted by clicking with the left mouse button into the fragment. Multiple fragments are selected by enclosing the fragments by dragging the cursor while keeping the left mouse button pressed. After releasing the mouse button selected fragments are highlighted. Confirm the selection by clicking the middle mouse button or the "*Enter*" key. See Figure 20.

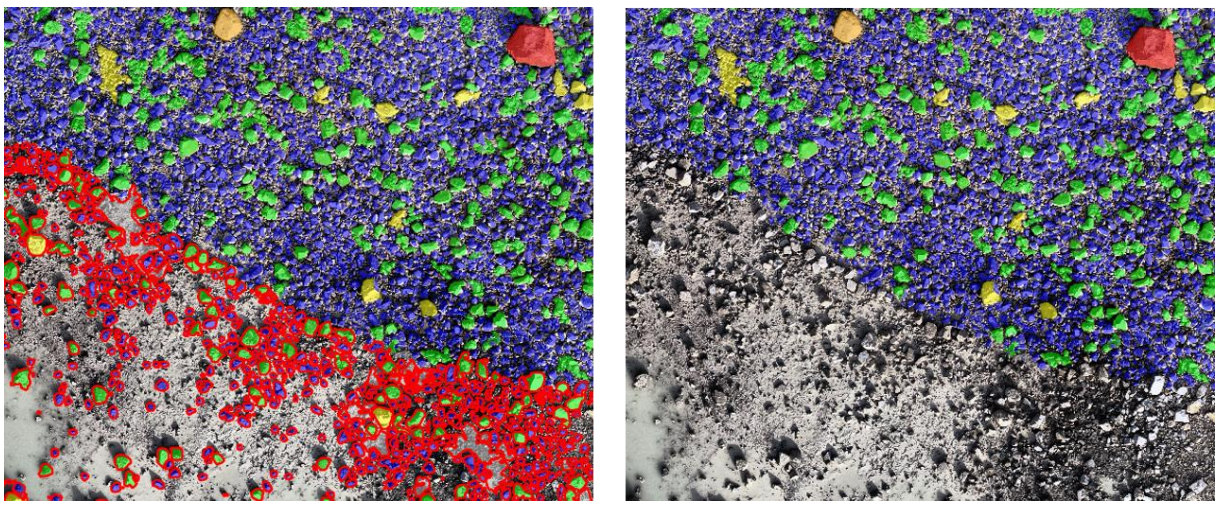


Figure 20: Deletion of multiple fragments

Editing of fragments

Activate the icon *"Edit Fragment"* in the toolbar and select the fragments to edit with the computer mouse. Moveable points of the boundary appear. Drag the points and adapt the shape of the particle with the left mouse button held and release the button at the desired position. See Figure 21.

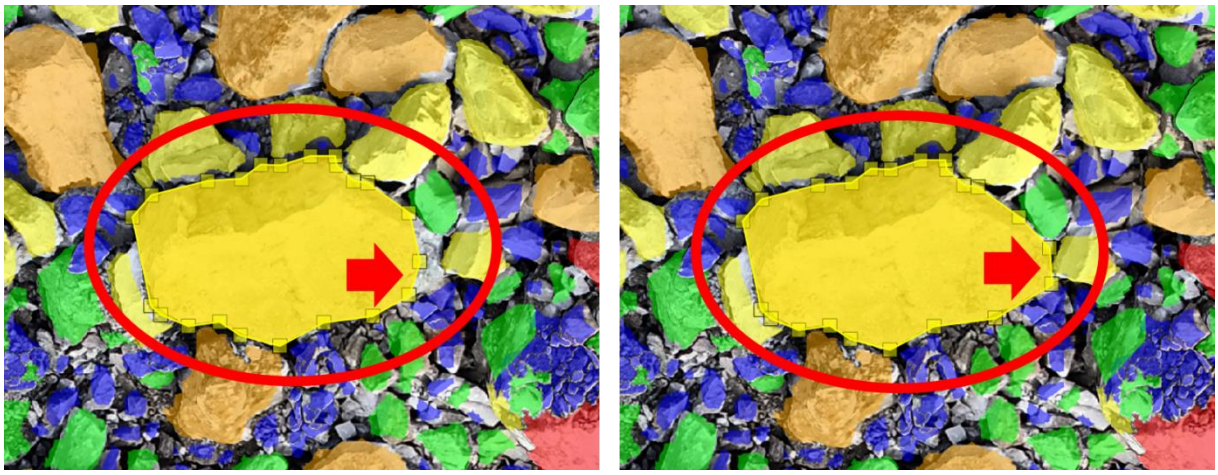


Figure 21: Editing a fragment by dragging the points of the boundary polygon

Add fragments

Activate the icon *"Add Fragment"* in the toolbar. Define the boundary of the fragment by clicking the left mouse button (Figure 22). A polygonal line grows instantaneously. Confirm the polygon by clicking the middle mouse button or the "*Enter*" key.

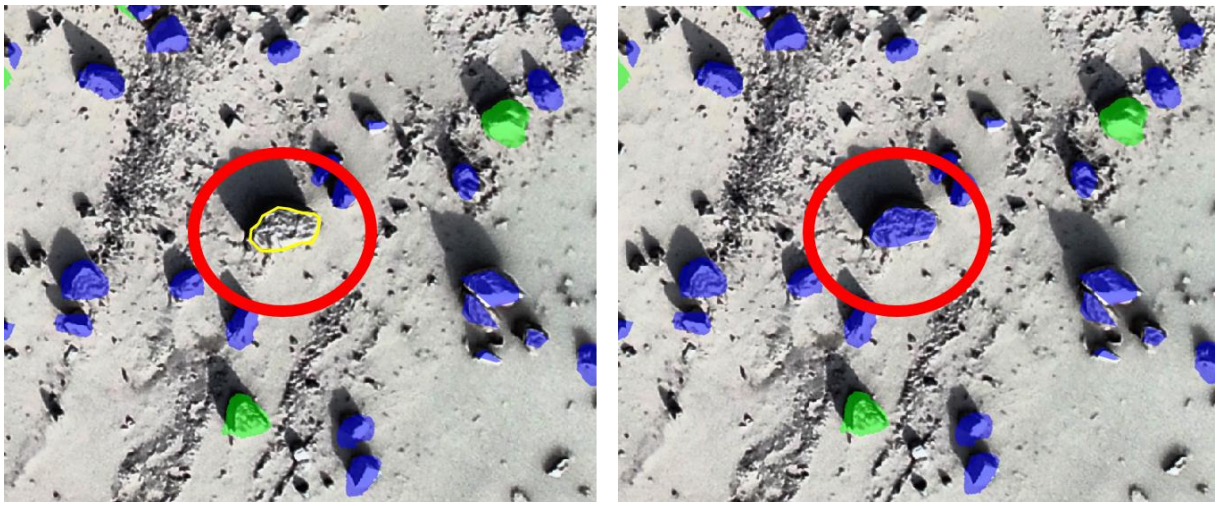


Figure 22: Adding a fragment by drawing a polygon

Note:
A particle has to be defined by at least five points.

Assignment of fragments

Activate the *"Assign new label"* icon in the toolbar. Select the desired type of fragment, i.e. *Particle*, *Border*, *Fines* or *Voids,* from the pull-down menu.

1. The selected label is assigned to a single fragment by clicking the fragment with the left mouse button.
2. The selected label is assigned to several fragments by enclosing the fragments with a polygon by dragging the cursor while keeping the left mouse button pressed. After releasing the mouse button selected fragments are highlighted. Confirm the selection by clicking the middle mouse button or the "*Enter*" key to assign the new label to the selected fragments. See Figure 23.

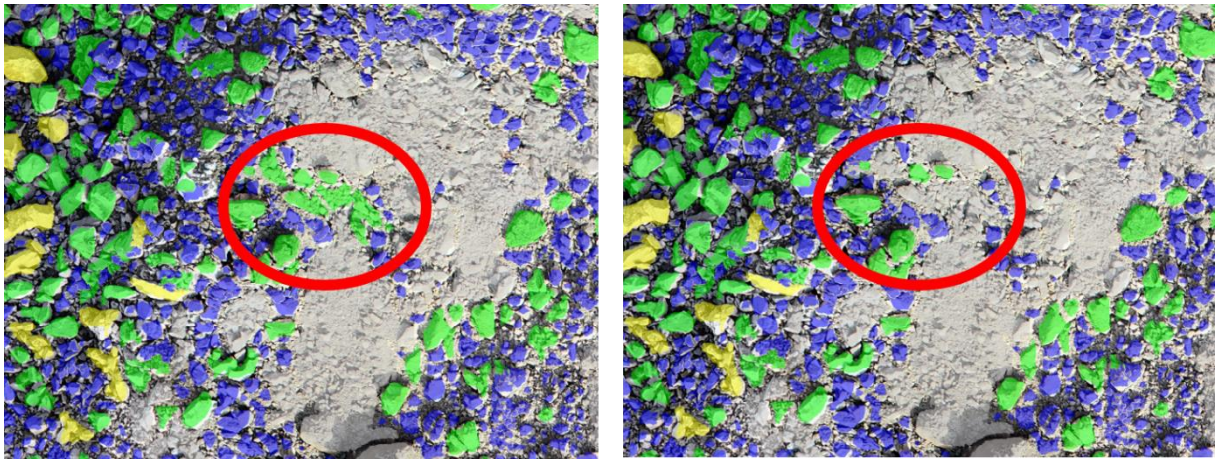


Figure 23: Assignment of Fines

5 Report and export

5.1 Report

The *BMX FragMetriX* automatically generates a report to a ".pdf" file by clicking *"File | Export Report to PDF"* (Figure 24). The report includes:

- key data of the current project (date of report generation, project name, data and description)
- *Particle Size Distribution Plot* with the corresponding parameters
- 2D image with the corresponding fragmentation analysis

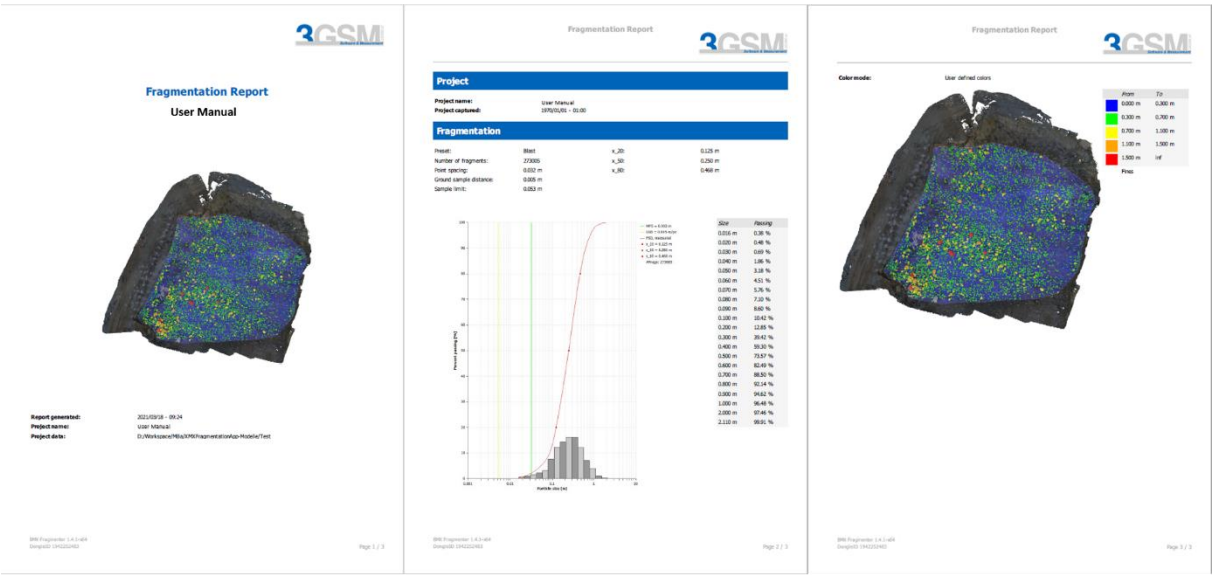


Figure 24: Automatically generated fragmentation report

Note:
User defined notes are added to the report in the dialog "*Edit Project Information"* (Figure 25) called up by the command *"File | Edit Project Information*" in the menu bar.

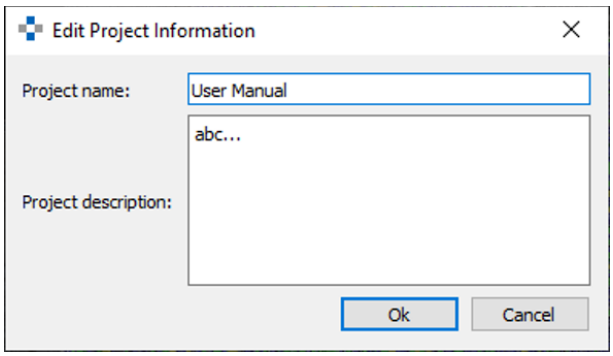
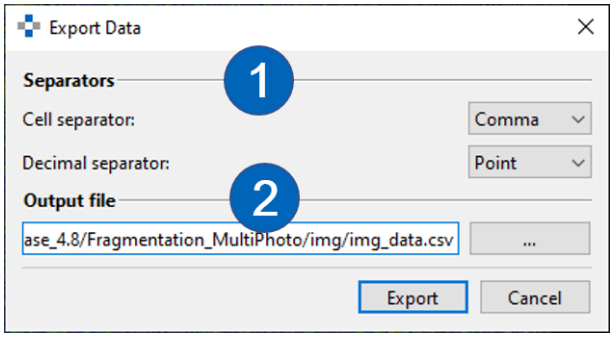


Figure 25: Project information

5.2 Export

The *Particle Size Distribution Plot* and the corresponding parameters are exported to ".csv" and ".pdf" by clicking *"File | Export Plot as CSV" and "File | Export Plot as PDF"* in the menu bar or by clicking the corresponding buttons in the *Plot* pane (see Chapter 3.7). The full set of data (see Data pane, Chapter 3.9) is exported by clicking *"File | Export Data as CSV"* in the menu bar or by clicking the corresponding button in the *Data* pane (see Chapter 3.9). The "csv" export can be configured by the user (see Figure 26).



1 Type of separator
2 Folder and name
Figure 26: Export dialog

Example *"Export Plot as CSV":*

```
"Geometry resolution [ m/px]";0,005320070629
"Median Point Spacing [m]"; 0,032237317413
"x20 [m]";0,188889413461
"x50 [m]";0,336822699881
"x80 [m]";0,565829249505
"Number of fragments";48308
"Percent passing [%]";"Particle size [m]"
0,000000000000;0,053207932002
0,260614956150;0,067511592007
…
```

Example *"Export Data as CSV":*

```
"ID";"Label";"Size [m]";"Percentage [%]"
738522;"Particle";0,053207932002;0,000057284661
760676;"Particle";0,053211167954;0,000040056192
751575;"Particle";0,053211772443;0,000090880176
755519;"Particle";0,053234657010;0,000104662952
761240;"Particle";0,053239746316;0,000052546832
730730;"Particle";0,053249151964;0,000048670426
…
```