GeoDict

GUI, Menu, and Toolbar Reference

User Guide

GeoDict release 2023

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GeoDict

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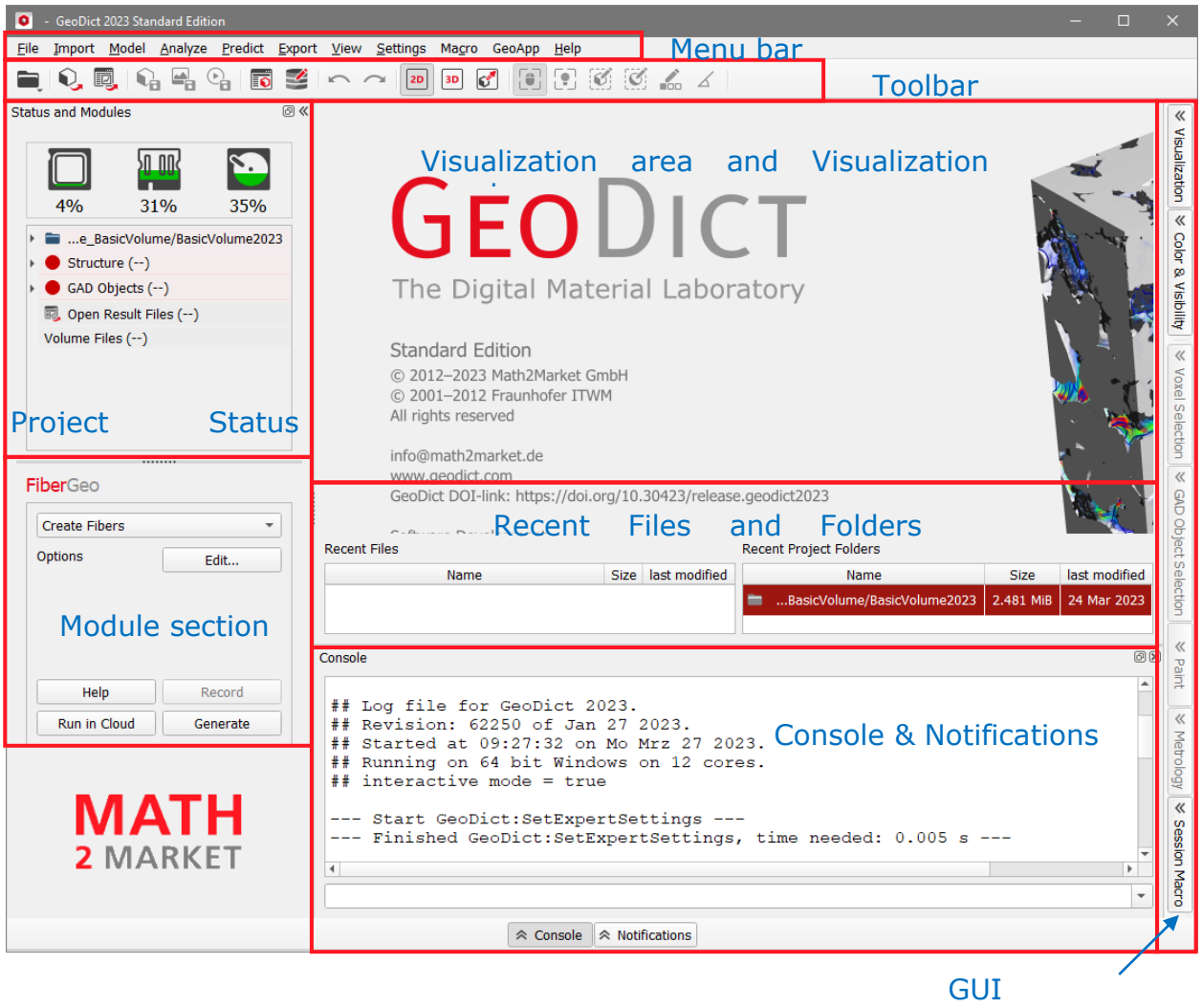
GeoDict GUI, Menu, and Toolbar

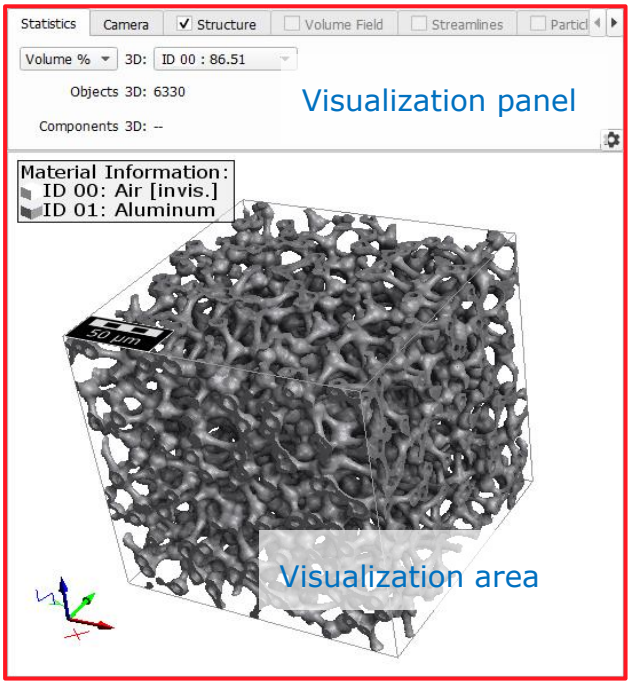
This handbook describes the basic elements of the GeoDict GUI (Graphical User Interface). The standard GUI is partitioned into:

- **Menu bar** (see page 4), that gives access to the main features of GeoDict,
- **Toolbar** (see page 3), that provides several shortcuts to the most common tools,
- **Project Status section** (see page 39), where information about the current project is shown and the loaded structure and volume fields can be edited in the right-click menu,
- **Module section** (see page 50), where commands and their options for the chosen module can be selected,
- **Visualization area** and **Visualization panel** (see page 51), where the structure is shown and visualization settings can be made,
- **GUI Sidebar** (see page 56), where modifications of the visualization or the structure can be made,
- **Recent Files and Folders** section (see page 2), which shows the last used folders and files on the start screen,
- **Console** and **Notifications** (see page 77), that display messages from GeoDict.



At the program start, the heading for the **Module** section is for one of the licensed modules, e.g., the FiberGeo module. The **Visualization area** shows the program's splash screen.

When a structure model is displayed, a **Visualization panel** with several tabs appears above the **Visualization area** to control the visualization of the structure or the results computed for it.

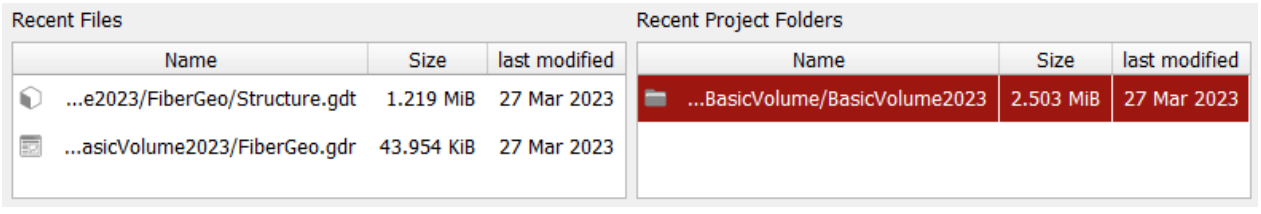


This handbook does not describe all features that can be accessed through the GUI. Features described in separate handbooks are not described here again. In this case, only a link to the handbook is provided.

A first overview of how a basic workflow in GeoDict might be performed is described in the First steps in GeoDict tutorial.

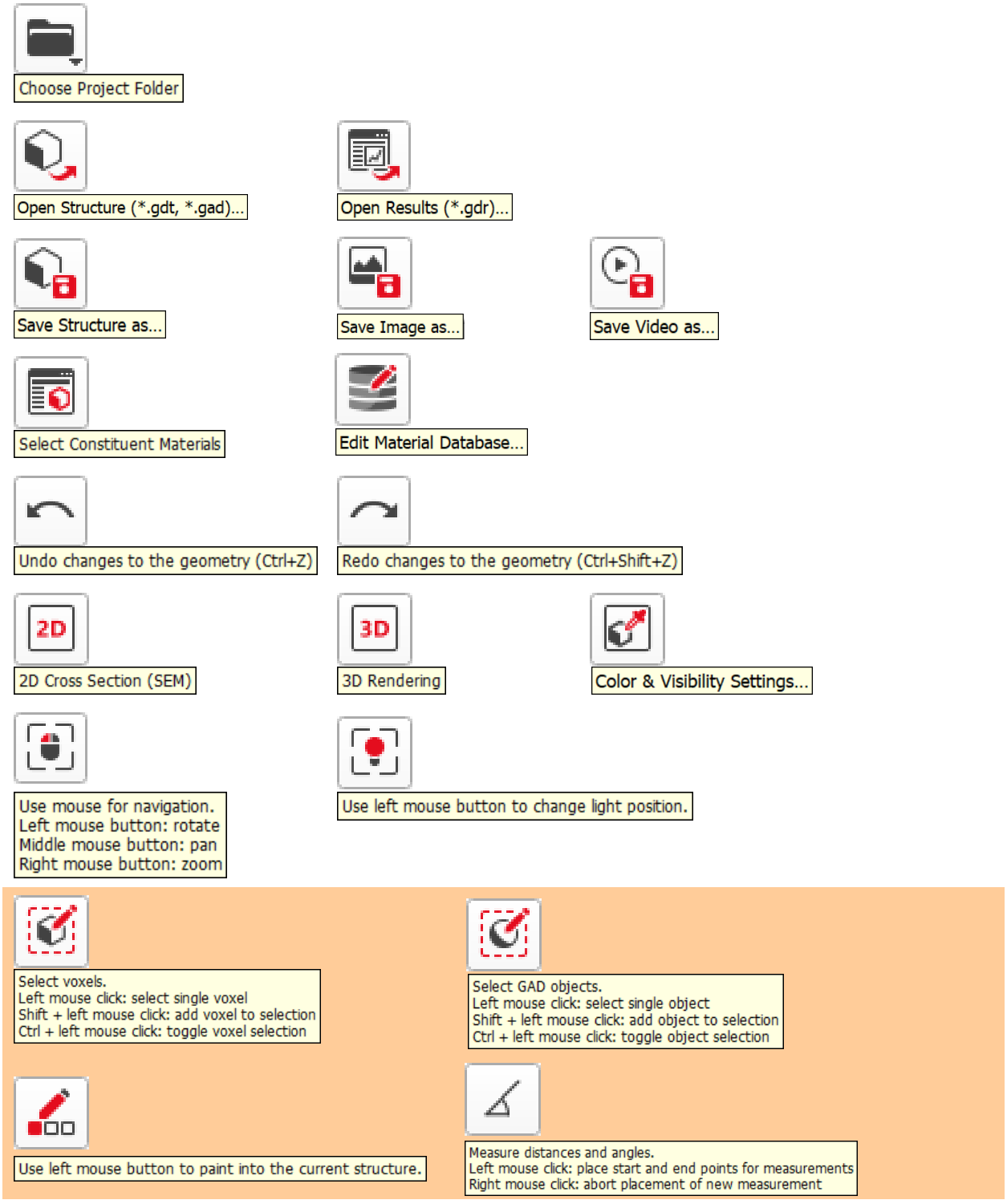
Recent Files and Folders

If no structure is in memory and the initial splash screen is shown, the **Recent Files** and **Recent Folders** sections are visible below. There, the **Name**, **Size** and date when it was **last modified** are shown. Clicking on a file opens it directly in the Visualization area or the Result Viewer. Clicking on a folder changes the current project folder.



TOOLBAR

The **Toolbar** displays tools for selected functions, mostly included in the **Menu bar**, frequently used in GeoDict. Resting the mouse pointer over a tool for a moment prompts a tool tip explaining the function.



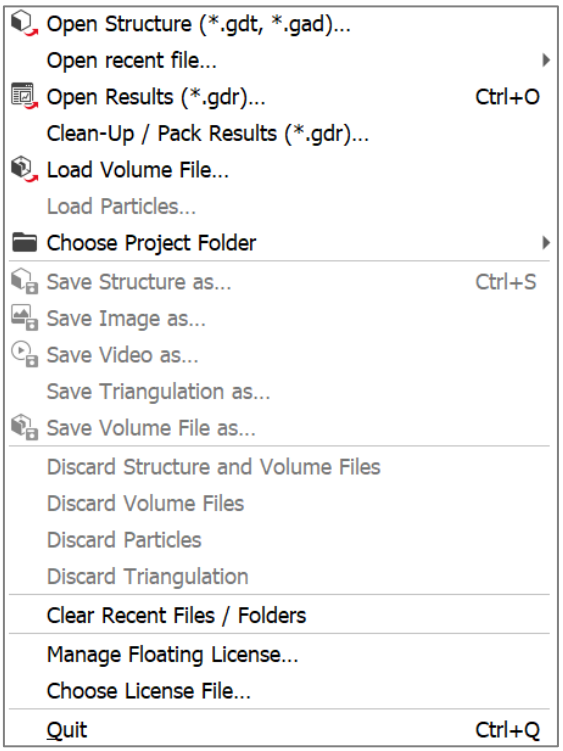
The selecting and editing functionality of Voxel Selection, GAD Object Selection, Paint and Metrology are part of the GUI Sidebar, and thus, are explained below starting on page 57.

MENU BAR

The **Menu bar** contains the menus: **File**, **Import, Model**, **Analyze**, **Predict**, **Export**, **View**, **Settings**, **Macro**, **GeoApp**, and **Help**. Their functions are accessible by scrolling down in the pull-down menus.

FILE

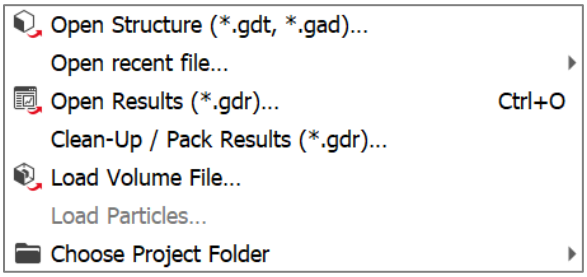
The **File** menu entries are organized into panels:



OPEN FILES, PACK AND LOAD RESULTS, PROJECT FOLDER

Open Structure (*.gdt, *.gad)

Select **Open Structure (*.gdt, *.gad) ...** to open a saved generated structure file in **GDT** format (GeoDict compressed format) or in **GAD** format (GeoDict analytic data). Such files are usually saved and, thus, located in a personal project folder created by the user for the current project.



Open recent file

Select **Open recent file...** to choose a file from a list, which is also shown in the Recent Files section (see page 2), with the files opened or created in the last GeoDict session.

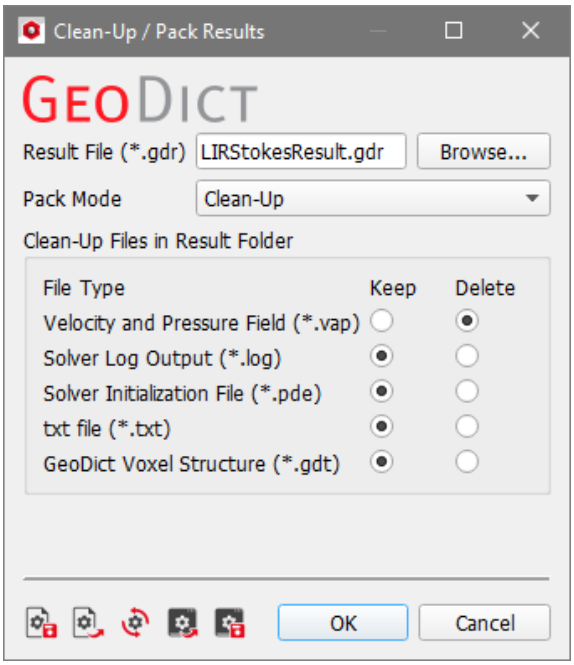
Open Results (*.gdr)

Select **Open Results (*.gdr)...** to open and load result files in **GDR** format (GeoDict results), obtained from a previous run of a GeoDict solver or structure generator, and saved in the project folder.

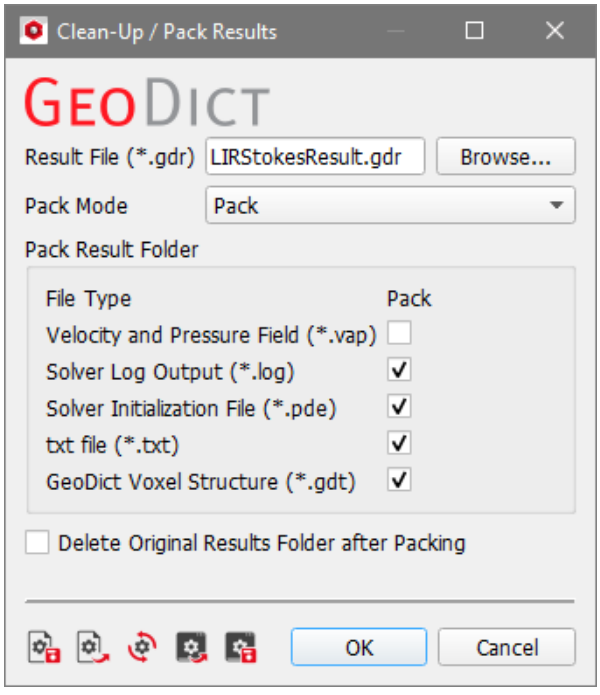
The toolbar icons  and  are the shortcuts to open structures and results.

Clean-Up / Pack Results (*.gdr)

Clean-Up / Pack Results (*.gdr)... allows to choose a result file and its result folder and to decide how the files that it contains should be handled.

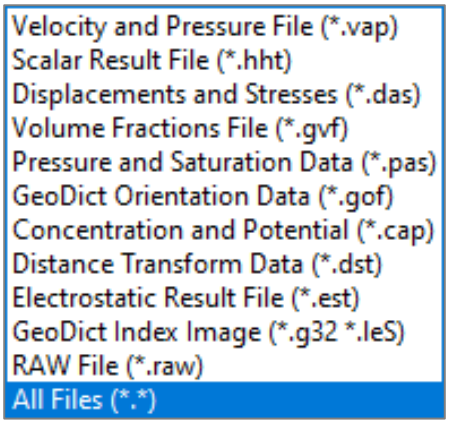


Choosing **Clean-Up** as Pack Mode, the user can decide if a particular **File Type** in the results folder should be kept or deleted. The results folder with the kept files and the chosen result file can be packed as ZIP-folder if **Pack** is chosen as Pack Mode. The original files can be kept or deleted after packing (**Delete Original Results Folder after Packing**).



Load Volume File

Select **Load Volume File...** to open volume files and visualize the contained volume fields, e.g., *.vap files (velocity and pressure) located in the result folders. The user can open and load result files for visualization in numerous formats.



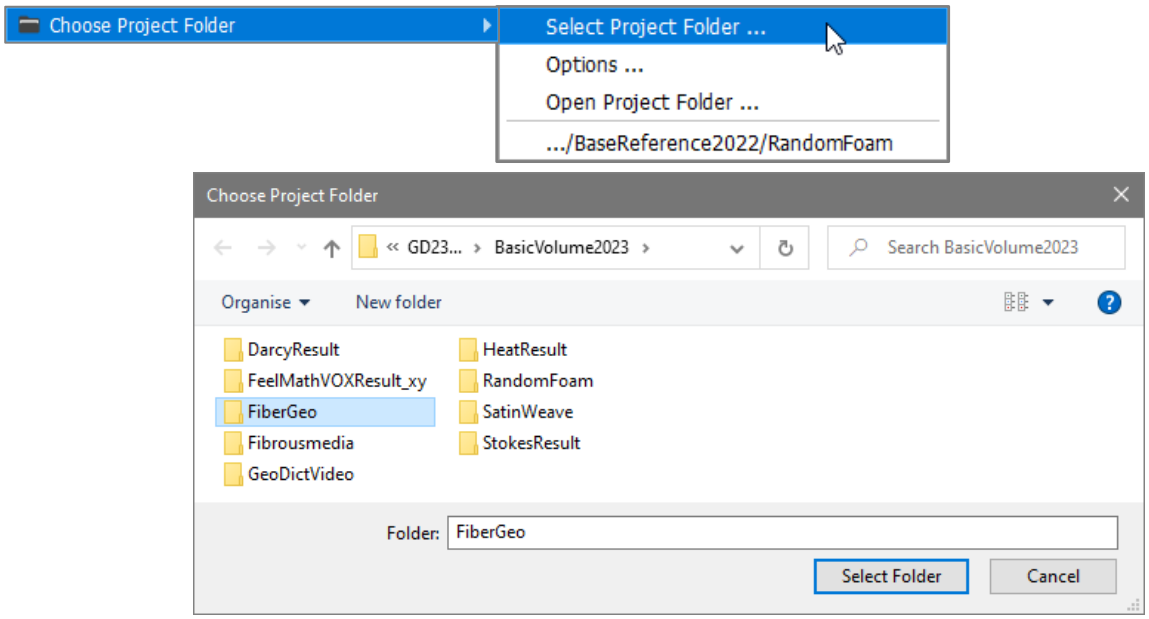
If a compressed volume field is opened, it is possible to load the field in compressed form or to decompress it during loading. A compressed field is saved when checking **Write Compressed Volume Fields** under the Solver tab of the **LIR Solver Options** dialog. Notice, that some operations and visualization features of volume fields are available only if the field is loaded in uncompressed form.

Load Particles

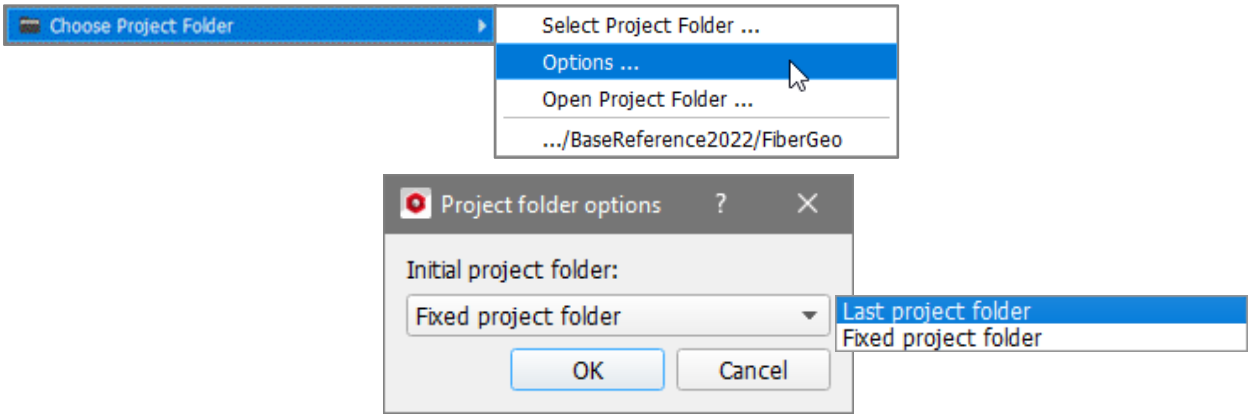
Select **Load Particles...** to open and visualize particle trajectories and particle positions for FilterDict or AddiDict simulations (*.gpt and *.gpp files). This option is only available if a structure is currently loaded into GeoDict.

Choose Project Folder

For **Choose Project Folder** a sub-menu opens when hovering above. Click **Select Project Folder...** to open the **Choose Project Folder** dialog. Find the path to a previously created and already listed project folder, or right-click in the dialog to create a new project folder to save the results and settings files produced with GeoDict.



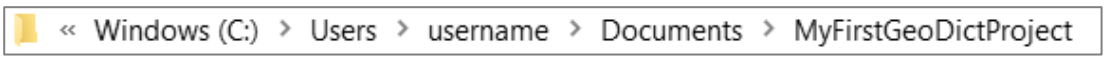
Follow **Choose Project Folder** → **Options...** to set up how the project folder is selected at the start of GeoDict. **Last project folder**, or a **Fixed project folder** can be selected.



Click **Open Project Folder** to open the currently selected project folder with the Windows Explorer. Below, if available, the last project folders are listed as it is done in the Recent Project Folder section (see also page 2).

The **project folder** will contain the files with the generated structures and the result files from the solvers' computations.

The location of the project folder is defined by the user at his/her convenience. The initial project folder for the first start of GeoDict, is located in Windows, by default at...

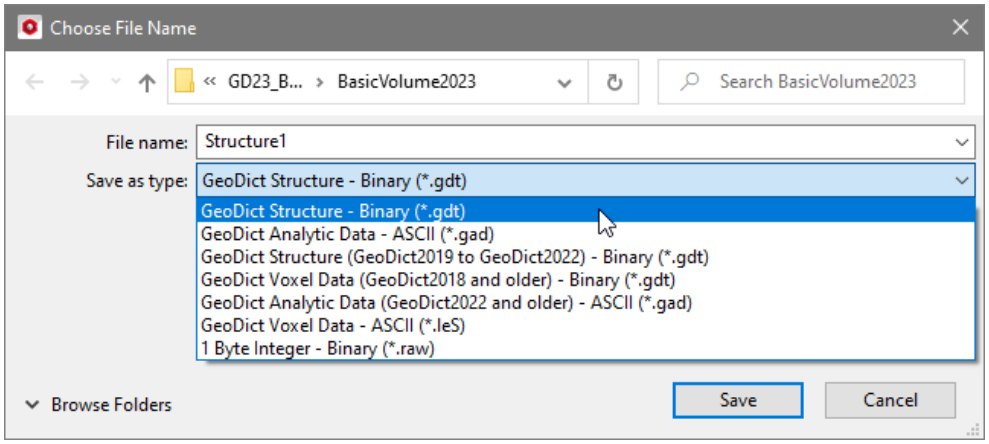


SAVE STRUCTURE, IMAGE, VIDEO, TRIANGULATION, OR VOLUME FILE

Save Structure

Select **Save Structure as...** to save the generated structure in the supported file formats (**GDT**, **GAD**, **leS**, and **RAW**).

The toolbar icon  is the shortcut to this function.

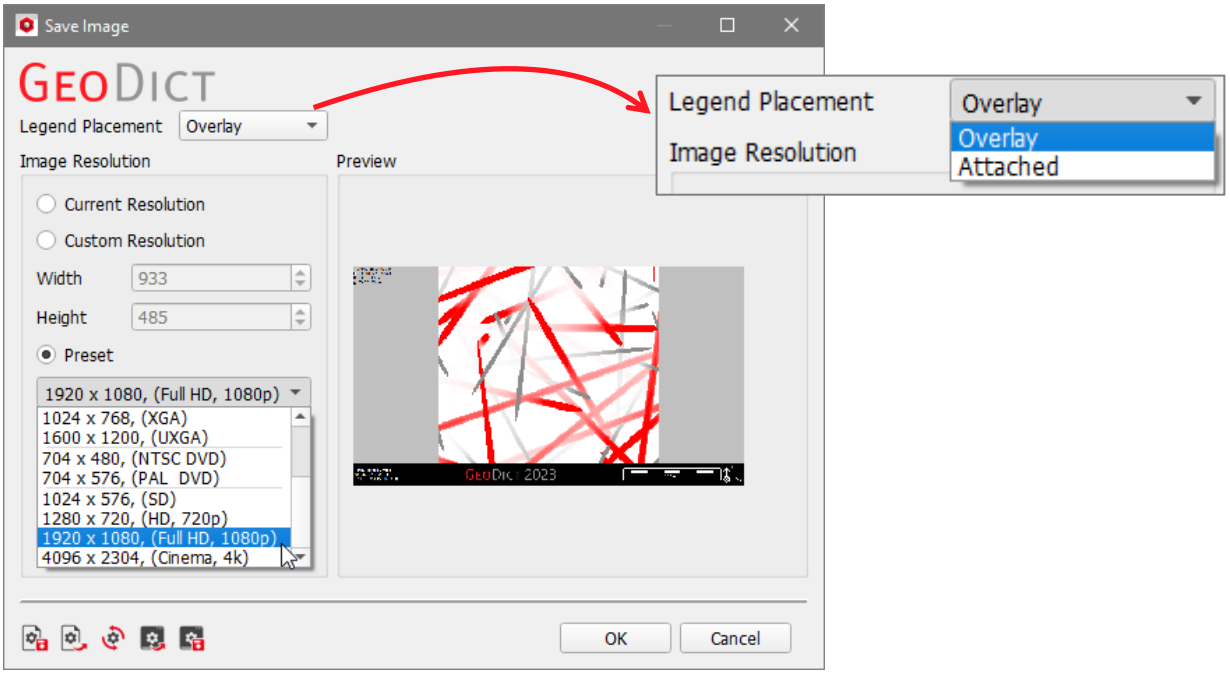


The automatically chosen folder to save the file containing the structure data is the current project folder. But it is also possible to choose another location.

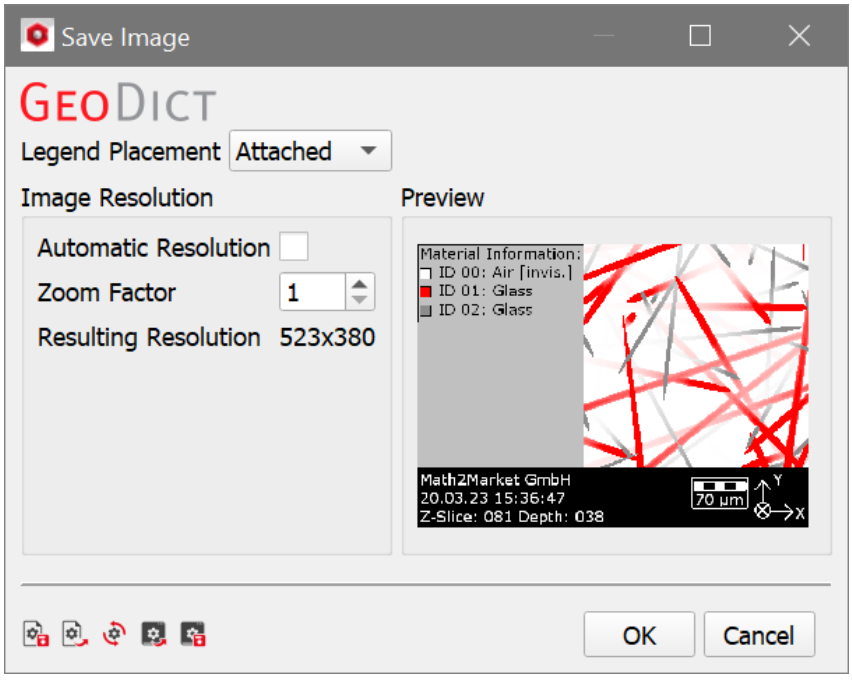
Save Image

Choosing **Save Image as...** saves the current image in the supported file formats (***.png**, ***.jpg**, ***.xpm**, ***.xbm**, ***.bmp**, ***.pgm**, ***.ppm**, and ***.pbm**) in the project folder. The toolbar icon  is the shortcut to this function. The opening dialog is different depending whether 2D view or 3D view was previously selected.

For 2D images, in the **Save Image** dialog that opens, select first where to place the legend in the image.

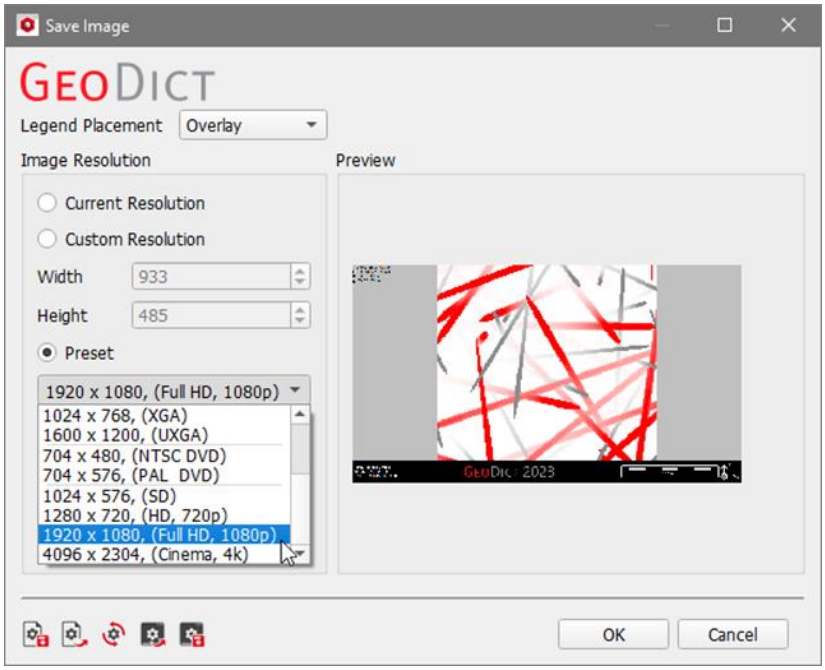


- Choose **Attached** to place the legend outside of the image but attached to it.



If this is selected, the resolution can be selected automatically or manually by defining a zoom factor. Uncheck the **Automatic Resolution** box, to set the zoom factor.

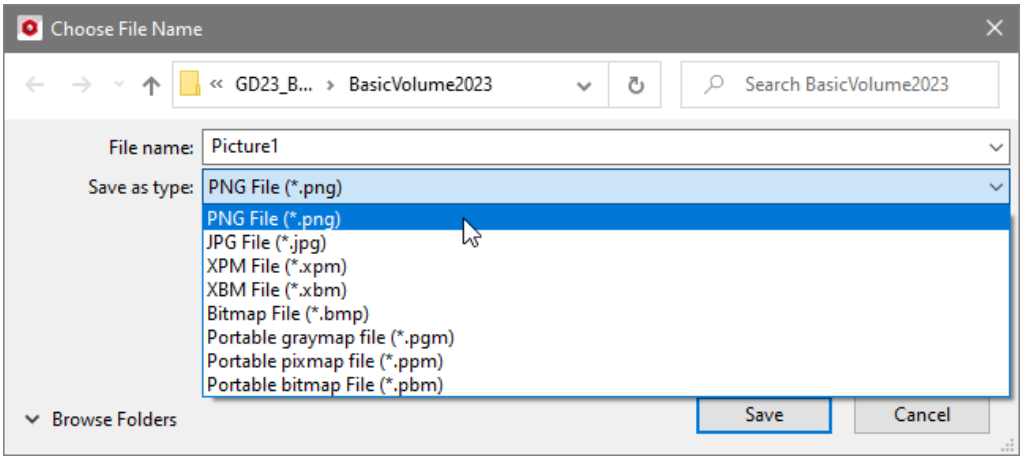
- Choose **Overlay** as the **Legend Placement** to allow that the legend overlaps the image.



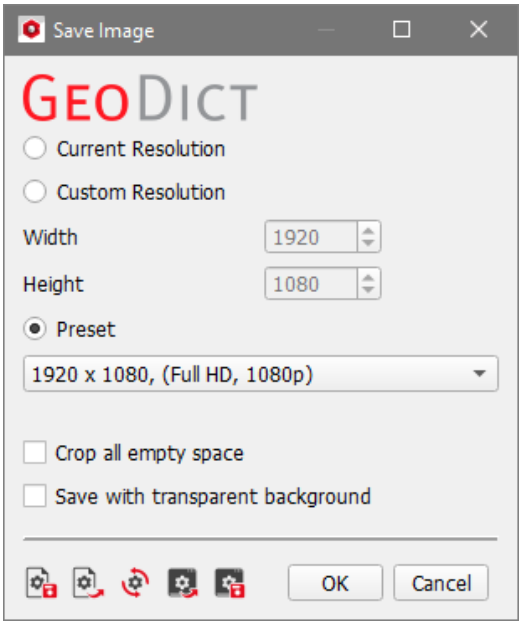
In this case, the user can choose to save the image with the **Current Resolution**, to define a **Custom Resolution** or to use the **Preset** resolution values that fits best.

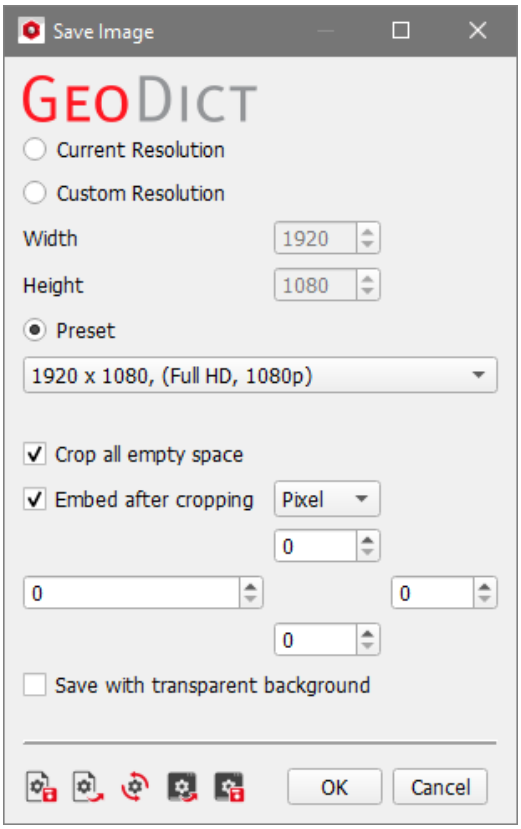
A preview of the image is shown in the right part of the dialog. Click **OK** to select the settings.

Choose a file name and an image format and save the image by clicking **Save**.



For 3D images, choose the resolution to save the image with the **Current Resolution**, define a **Custom Resolution** or use a **Preset** resolution.





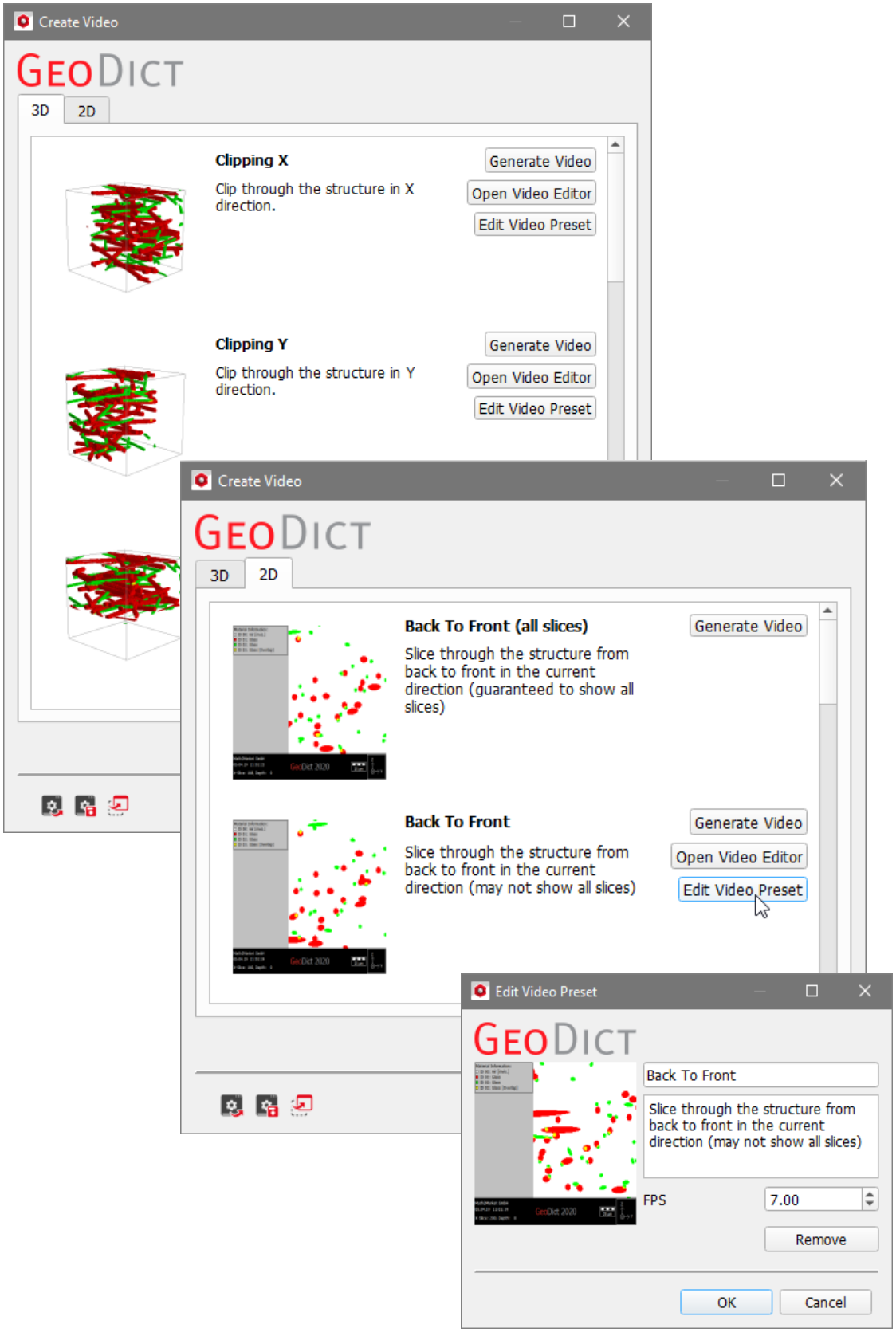
Select **Crop all empty space** to reduce the image size by removing all borders in background color.

If this is selected, the image can be embedded in borders with the background color **(Embed after cropping)**. The number of pixels for each border can be defined separately in this case.

Finally, check **Save with transparent background** to save the image without a background color.

Save Video

Selecting **Save Video as...** opens the Create Video dialog, which allows choosing preset scripts that execute the making of a video with appropriate standard settings. The preset video scripts are organized in the two tabs 2D and 3D. Clicking on **Generate Videos** opens the Save Videos dialog, where the output options like the video file name can be entered. The video is then created without any modifications of the underlying script. Click **Open Video Editor** to open the Video Editor for modifications. **Edit Video Preset** allows to change the description of the video preview.



The following preset movie clips are available:

- In 3D: **Clipping X**, **Clipping Y**, **Clipping Z**, **Fly-by**, **Follow Particle**, **Particle Animation**, **Rotate X**, **Rotate Y**, **Rotate Z**, and **Streamlets**. Also given is the option to import settings from the Video Dialog 3D to be listed in the preset video scripts (**Import as Video GeoApp**), to produce a 3D video using 2D images from a stack of scanned images (**Create Video from Image Stack**),

and to simply open the Video Dialog 3D editor without loading a specific preset video script (**Open Editor**).

- In 2D: **Back To Front (all slices)**, **Back To Front**, **Front To Back (all slices)**, **Front To Back**, **Import as Video GeoApp**, **Create Video from Image Stack**, and **Open Editor**.

See the Create Videos handbook for more details about creating videos in GeoDict.

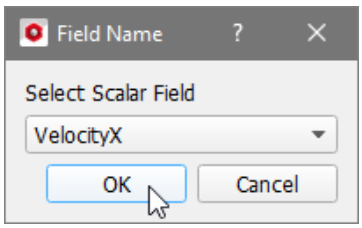
The use of **Save Image as... and Save Video as...** are excellent and easy-to-use choices when the user intends to present to the public structures and visualized results after working with GeoDict.
The high resolution achievable when saving images or videos this way is suitable for press-ready flyers and posters.

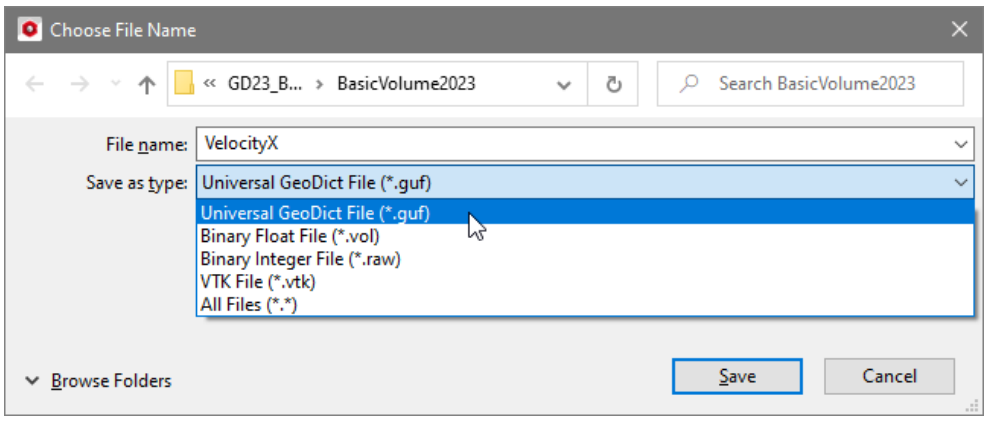
Save Triangulation

Select **Save Triangulation as...** to save triangulations obtained by creating a mesh through MeshGeo or by importing in ImportGeo-CAD.

Save Volume File

Select **Save Volume File as...** to save simulation results in several file formats. For example, after running a flow simulation with FlowDict, select a name to save the field of the velocity in X-direction as raw float data (*.vol) or GeoDict universal file (*.guf).

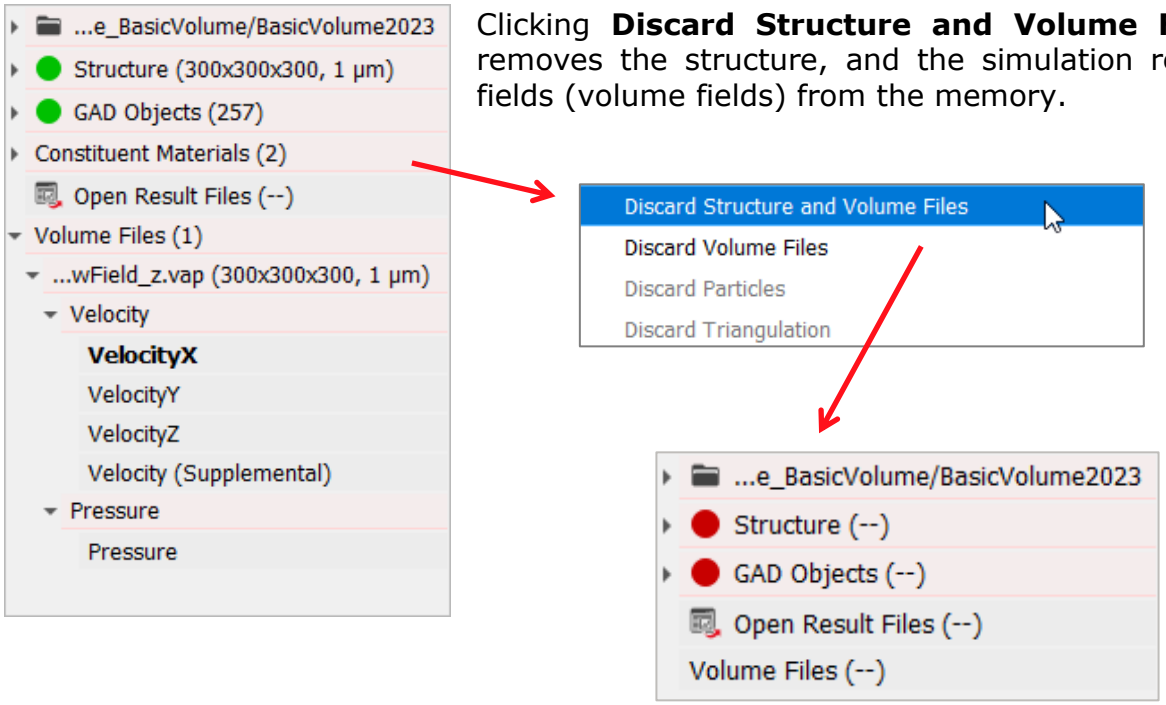




DISCARD STRUCTURE OR SIMULATION RESULTS

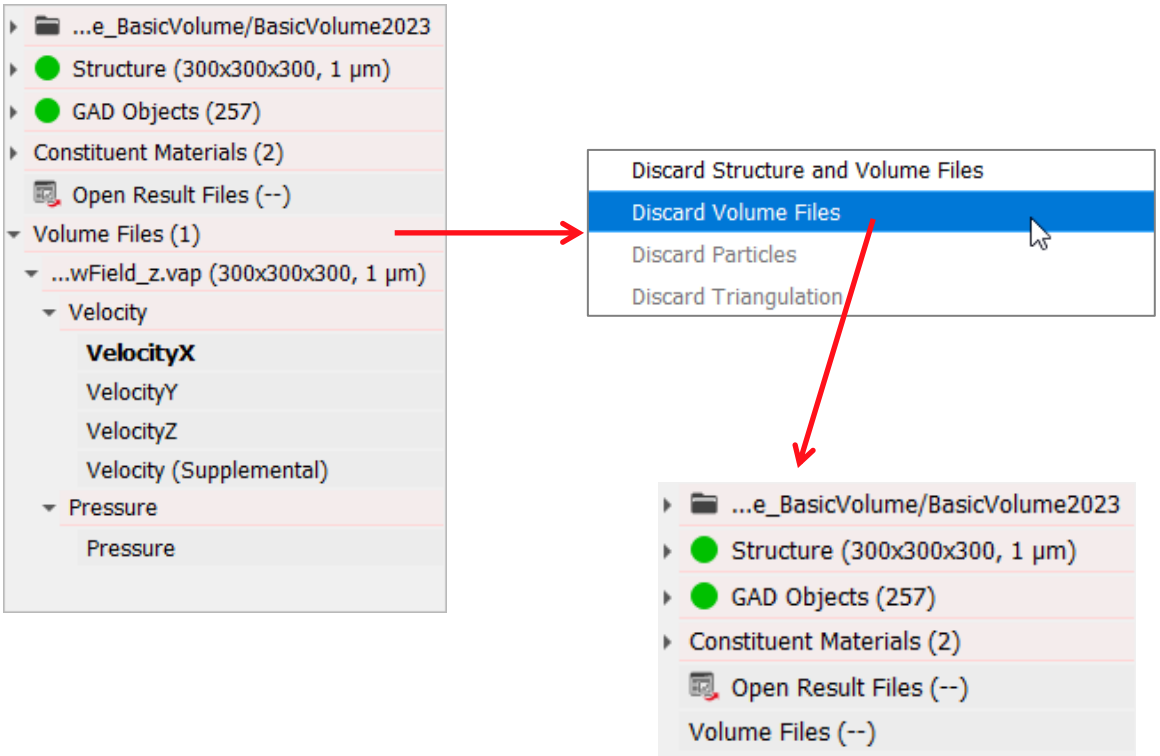
Selecting **Discard Structure and Volume Files** makes the structure, and all simulation result fields available for this structure, disappear from memory and from the Visualization area. The initial GeoDict splash screen appears in the Visualization area instead.

In the example shown here, a fiber structure is loaded in GeoDict, together with the volume fields of velocities in X-, Y- and Z-direction, loaded from the .vap file of a flow simulation.



Clicking **Discard Structure and Volume Files** removes the structure, and the simulation result fields (volume fields) from the memory.

Selecting **Discard Volume Files** eliminates only the simulation result fields (volume fields) of the structure displayed in the Visualization area from memory.



In the same way, for a particle simulation result (created with FilterDict or AddiDict), if particle trajectories or positions are available in GeoDict memory, **Discard Particles** removes the particle information from memory.

A structure in STL format (Stereosurface triangulation language), imported with ImportGeo-CAD, and shown in the Visualization area, is deleted from memory when **Discard Triangulation** is selected.

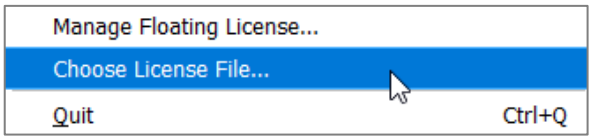
Clear Recent Files / Folders

Clicking **Clear Recent Files / Folders** clears the list of Recent Files and Recent Project Folders shown in the GUI.

Manage Floating License, Choose license file, and Quit

Clicking **Manage Floating License...** allows a floating license user to choose which of the licensed modules he would like to use in this session. Deselected modules will be shown as unlicensed in GeoDict's menu, and their license will then be free for other users to use.

Select **Choose License File...** to select a license file, e.g., to change the license from evaluation to purchased or leased license, to upgrade the license for another term, or to request a new license file following the procedure explained in **Licensing** GeoDict in the Download, Installation and Licensing handbook of this User Guide.



Selecting **Quit** ends the current GeoDict session.

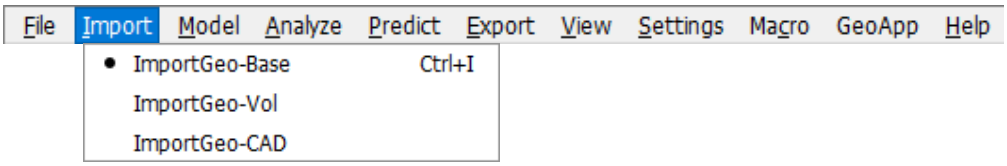
IMPORT

Accessible from the menu bar are interfaces to import image and structure files into GeoDict (ImportGeo).

For many image file formats, ImportGeo can perform 3D processing on gray value images and import them to the index image characteristic of GeoDict. The extraction from gray value images is done by segmentation, a procedure to convert them to index values. ImportGeo can also be used to load, import, and visualize a structure in the formats supported by GeoDict.

ImportGeo-Base always appears in the menu because it is included in the GeoDict Base Package, other modules that have not been licensed appear under **unlicensed** in the list.

Start an ImportGeo module by clicking **Import** in the menu bar and selecting one of the sub-modules available to import a file into GeoDict. If a module is selected, a dot appears in front of it in the module list and the module section changes to show this module.



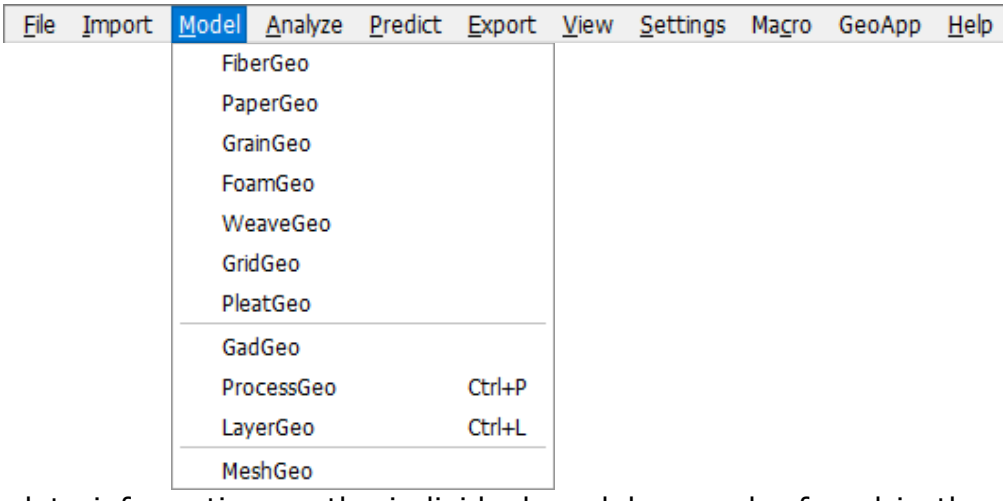
For complete information on interfaces to GeoDict see:

- the ImportGeo-Base handbook (here, also an overview of all supported file formats can be found),
- the ImportGeo-CAD handbook,
- and the ImportGeo-Vol handbook of the User Guide.

MODEL

The **Model** menu gives access to the list of modules for digital material modeling that are included in the user's license. GadGeo, ProcessGeo, and LayerGeo can always be used because they are included in the GeoDict Base Package. Other modules that have not been licensed appear in the list under **unlicensed**.

The GeoDict modules for digital material design available for licensing are:



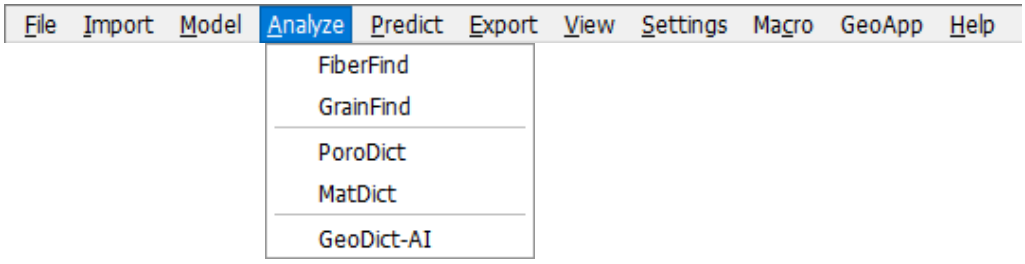
The complete information on the individual modules can be found in the module's handbooks:

- FiberGeo handbook
- PaperGeo handbook
- GrainGeo handbook
- FoamGeo handbook
- WeaveGeo handbook
- GridGeo handbook
- PleatGeo handbook
- GadGeo handbook
- ProcessGeo handbook
- LayerGeo handbook
- MeshGeo handbook

ANALYZE

The **Analyze** menu gives access to the list of modules for digital material analysis that are included in the user's license. Modules that are not licensed appear in the list under **unlicensed.**

The GeoDict modules for digital material analysis available for licensing are:



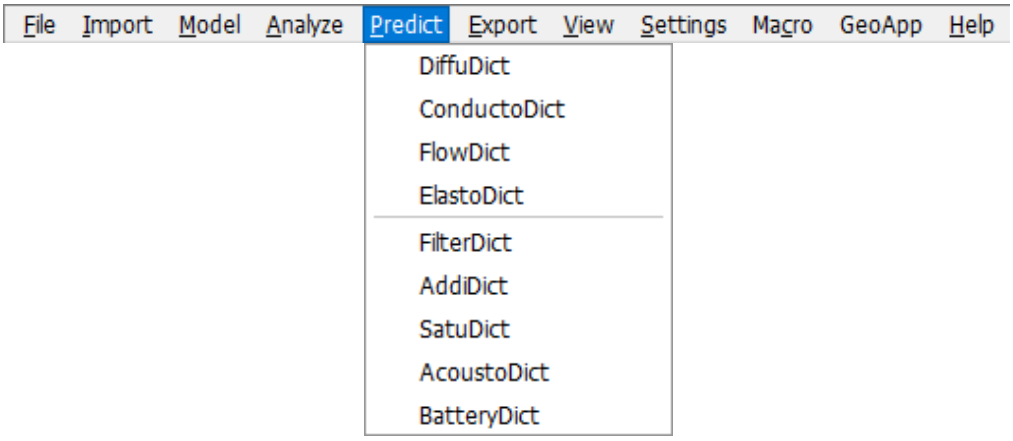
The complete information on the individual modules can be found in the module's handbooks:

- FiberFind handbook
- GrainFind handbook
- PoroDict handbook
- MatDict handbook
- GeoDict-AI handbook

PREDICT

The **Predict** menu gives access to the list of modules for the prediction of material properties that are included in the user's license. Modules that are not licensed appear in the list under **unlicensed.**

GeoDict modules available for prediction of material properties are:



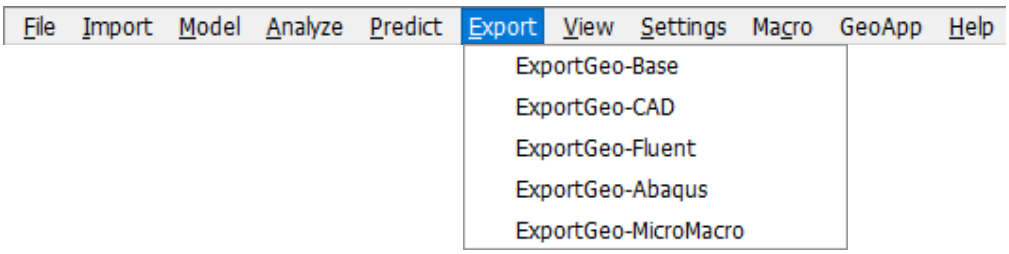
The complete information on the individual modules can be found in the module's handbooks:

- DiffuDict handbook
- ConductoDict handbook
- FlowDict handbook
- ElastoDict handbook
- FilterDict handbook
- AddiDict handbook
- SatuDict handbook
- AcoustoDict handbook
- BatteryDict handbook

EXPORT

Accessible from the menu bar are interfaces to export structure files, images, and simulation results from GeoDict (ExportGeo) to many other software packages.

To export a GeoDict file to other formats, select **Export** in the menu bar, and choose between ExportGeo-Base, ExportGeo-CAD, ExportGeo-Fluent, ExportGeo-Abaqus and ExportGeo-MicroMacro.



With ExportGeo, structures from GeoDict can be exported to other formats so that files produced by the GeoDict user are compatible with other software and can be used for customized workflows:

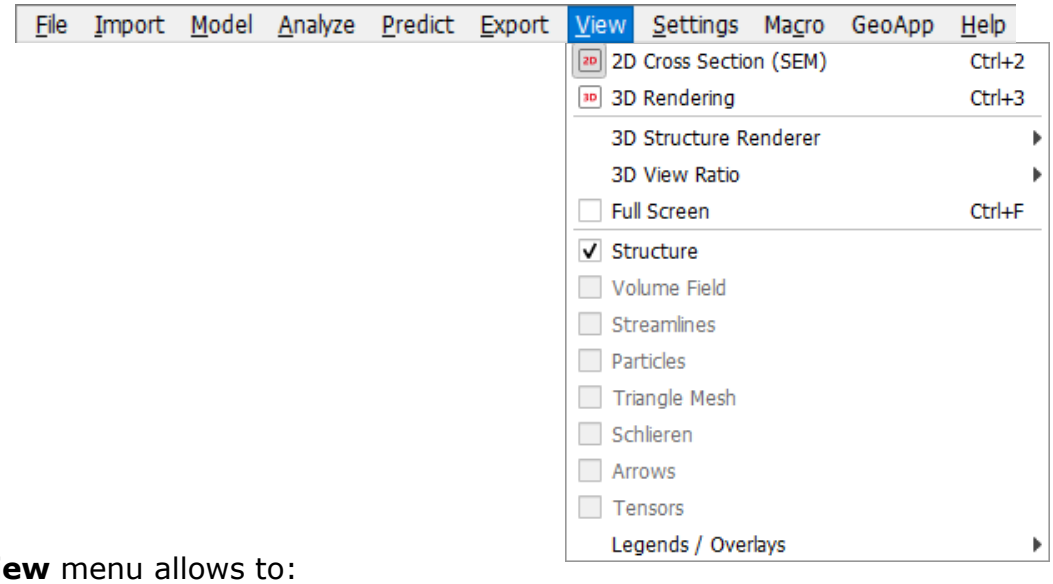
- ExportGeo–Base converts voxelized data to RAW, VOL, PNG and Avizo Binary File (.am) formats. Furthermore, it converts analytic data, particles, trajectories and streamlines to GeoDict's GAD format.

- ExportGeo-CAD converts voxelized or analytic structures to commonly used surface triangulation and CAD formats like STL, VRML, or Parasolid.
- ExportGeo-Fluent and ExportGeo-Abaqus convert voxelized data to formats for flow and heat computations with **Fluent™** or elasticity computations with **Abaqus**.

For complete information on interfaces from GeoDict, see the ExportGeo-CAD / MeshGeo handbook, the ExportGeo-Fluent handbook, and the ExportGeo-Abaqus handbook of the User Guide.

VIEW

After modeling a structure, either by generating it in GeoDict or after importing 3D µCT or FIB/SEM images, choosing between the **View** menu entries changes the visualization settings. A shortcut to many of these parameters can also be set through the Visualization Side Bar, as explained shortly below, starting on page 56, and in more detail in the Visualization handbook.

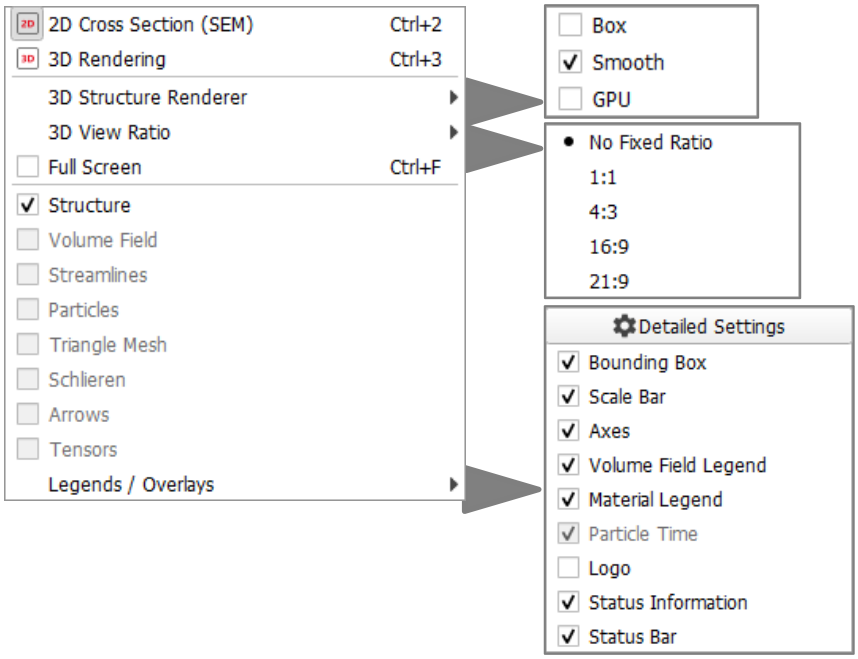


The **View** menu allows to:

- choose the visualization type to be **2D Cross Section (SEM)**, or **3D Rendering**, with **3D Structure Renderer** and the **3D View Ratio**.
- display the Visualization area in **Full Screen** which makes the Visualization area occupy the entire computer screen. Pressing the **Esc** key on the keyboard returns the program to the normal display.
- select which components are displayed in the **visualization**.
- choose the **Legends / Overlays** to be displayed.

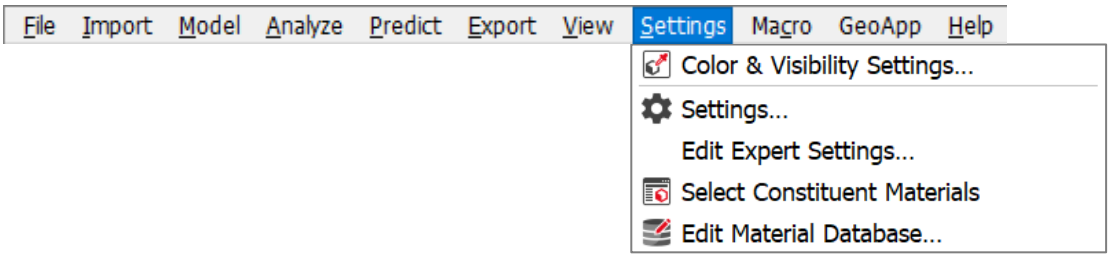
Some of these options are only accessible when choosing to visualize in **3D Rendering** or when visualizing solver results (**Volume Field**, **Streamlines**, **Particles**, **Triangle Mesh**, **Schlieren**, **Arrows**, and **Tensors**).

Choose **Legend / Overlays → Detailed Settings** to access the Visualization Side Bar, see page 56 and the Visualization handbook.

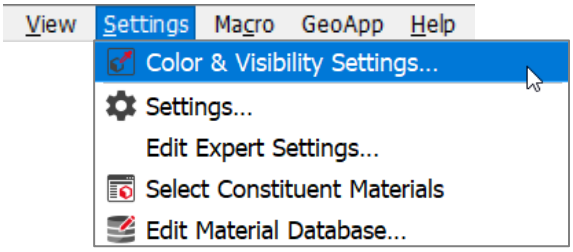

2D Cross Section (SEM) Ctrl+2
3D Rendering Ctrl+3
3D Structure Renderer
3D View Ratio
Full Screen Ctrl+F
Structure
Volume Field
Streamlines
Particles
Triangle Mesh
Schlieren
Arrows
Tensors
Legends / Overlays
Box
Smooth
GPU
No Fixed Ratio
1:1
4:3
16:9
21:9
Detailed Settings
Bounding Box
Scale Bar
Axes
Volume Field Legend
Material Legend
Particle Time
Logo
Status Information
Status Bar

SETTINGS

The **Settings** menu includes **Color & Visibility Settings**, **Settings**, **Edit Expert Settings**, **Select Constituent Materials**, and **Edit Material Data Base**.



COLOR & VISIBILITY SETTINGS

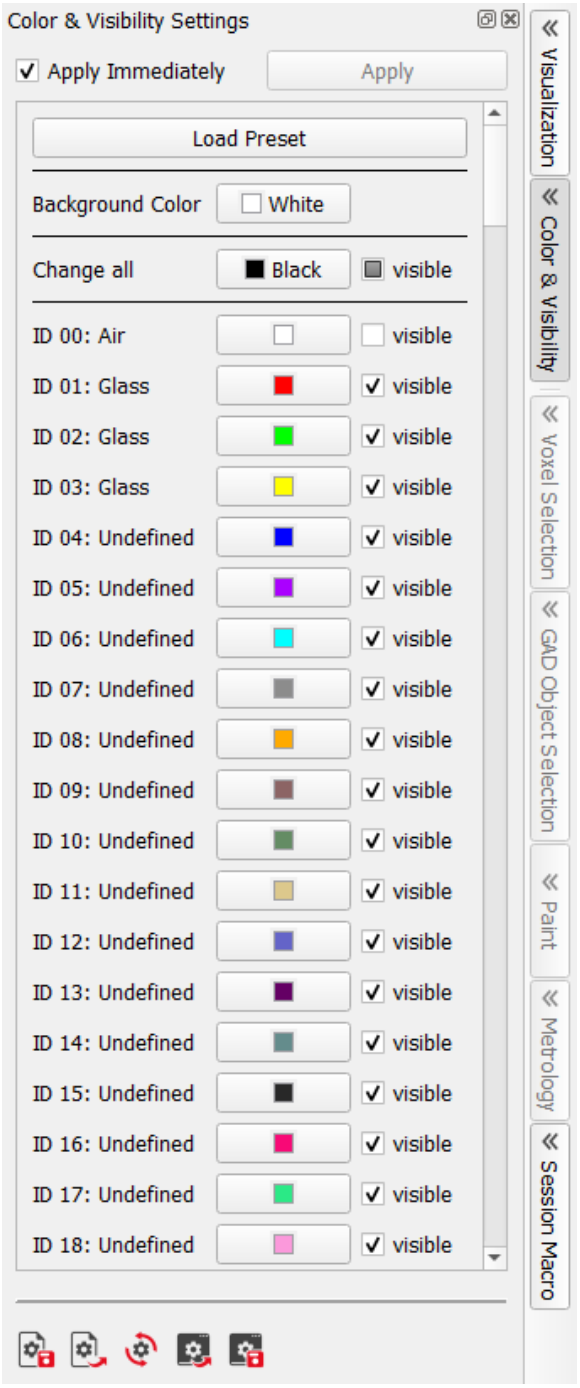


The default color settings applied to the background and materials during the generation with GeoDict, can be changed through the **Color & Visibility Settings** dialog, that opens from the GUI Sidebar on the right of the Visualization Area.

If a structure is currently in memory, only the Material IDs present in the structure are editable in the Color & Visibility settings, otherwise all 256 Material IDs are displayed.

First, decide whether the settings made should be applied directly to the structure in memory by checking **Apply Immediately**. Otherwise the **Apply** button must be pressed.

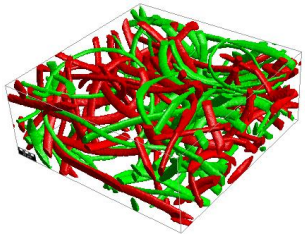
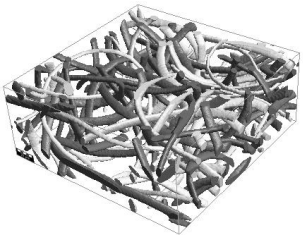
A color preset is a particular group of colors that are applied together. Click **Load Preset** and, in the **Load Color Preset** dialog, select whether to display the generated structure's materials using one of the presets.



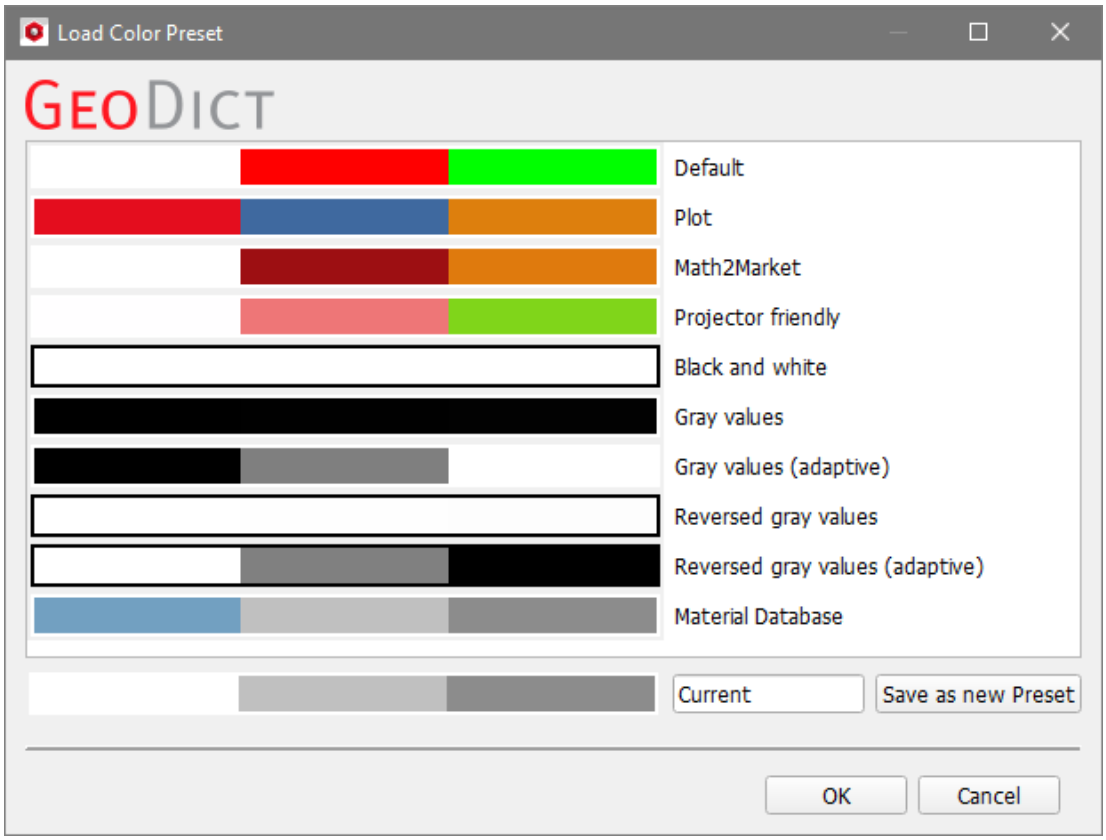
Change all allows to change the color of all material IDs to the same color. By checking **visible** all material IDs can be set to be visible at once.

Below, this can also be done for each material ID separately.

Keeping a **Color & Visibility Settings** dialog open, instead of closing it, is helpful when trying to find the most adequate settings for a particular visualization.

Default	Gray values	Reversed gray values
		

After selecting new colors through the buttons in the **Color & Visibility Settings** dialog, the current group of colors can be saved as a preset (**Load Preset → Save as new Preset**), to have it appear in the list of color presets later.

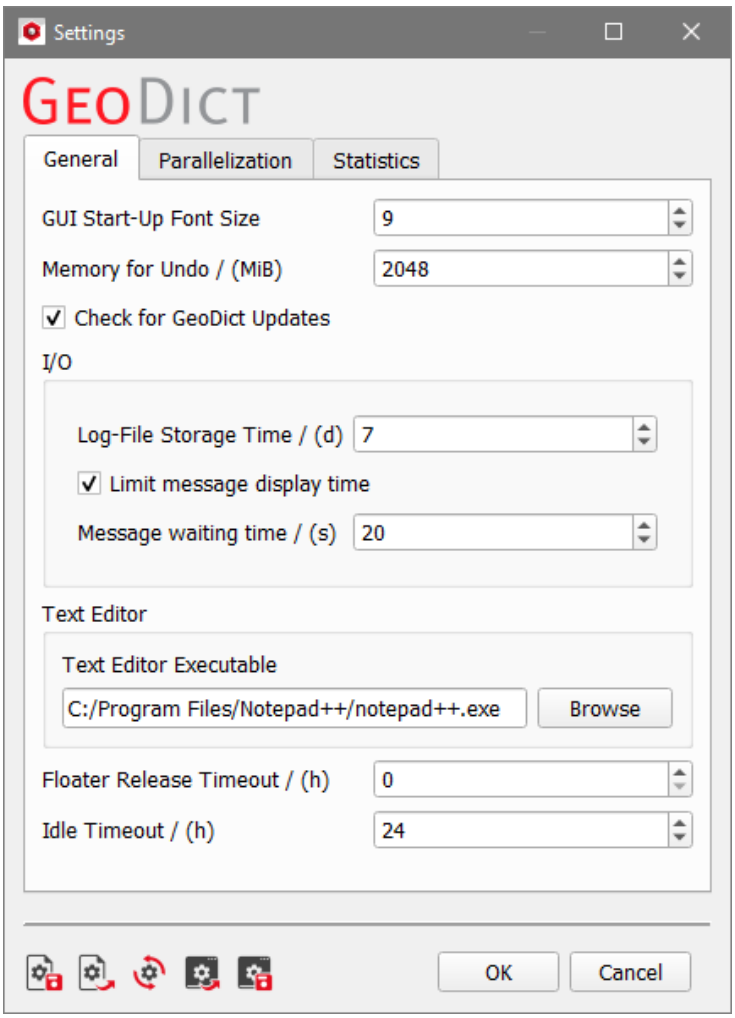


More details about the GeoDict colors and visibility settings can be found in the Visualization handbook.

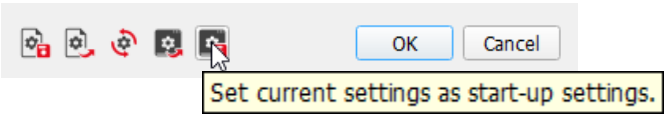
SETTINGS

Selecting **Settings...** from the **Settings** menu opens the **Settings** dialog to modify the general preferences or properties when working with GeoDict. The dialog contains the **General, Parallelization** and **Statistics** tabs.

They contain a collection of settings that a user typically wants to apply to any GeoDict session.



Resting the mouse pointer over the icons in the lower left of settings dialogs prompts a tool tip showing the icon's function to appear. For example, if the chosen setting should not apply only to this GeoDict session but should also be chosen at the next GeoDict startup, the user must, after making his choices, first click the icon at the bottom of the dialog:



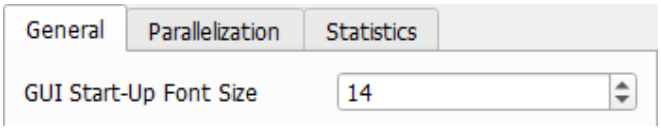
After setting the current settings as start-up setting, click **OK**.

The parameters entered in the **Settings** dialogs can also be saved into GPS (*.gps, GeoDict Project Settings) files and/or loaded from them.

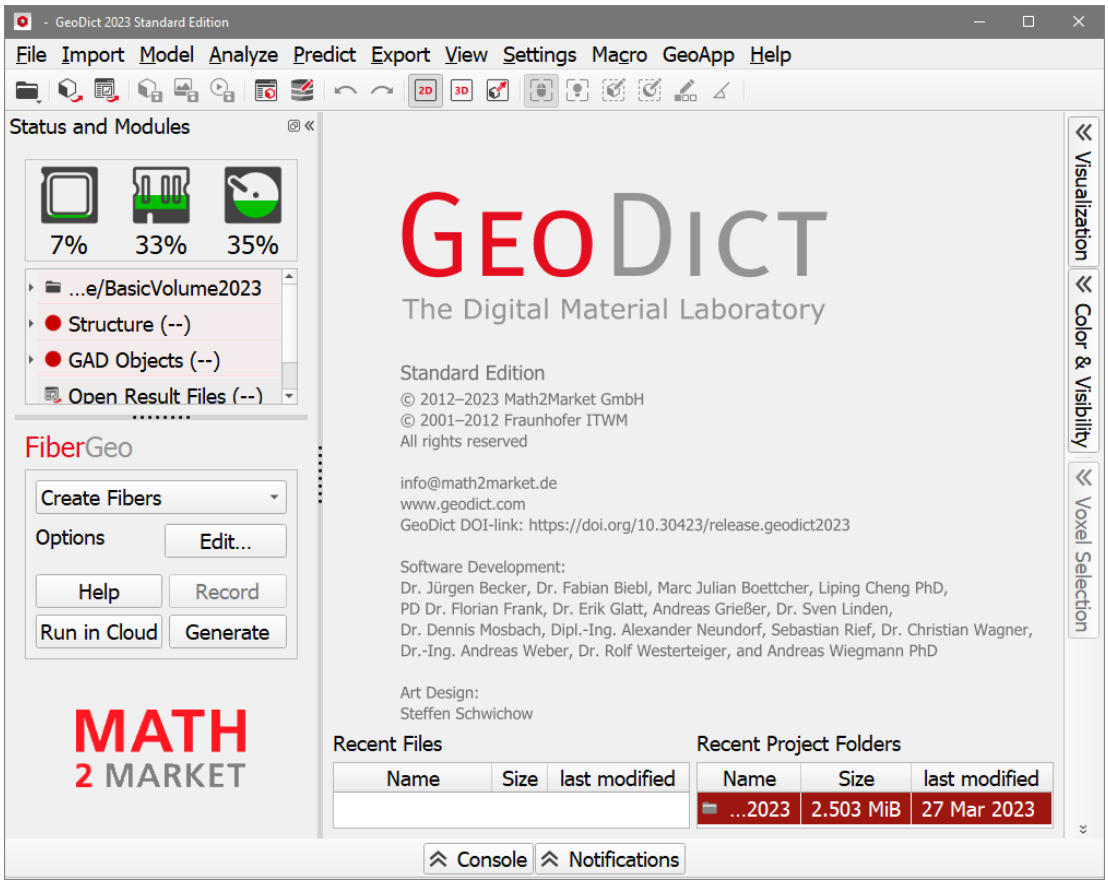
Clicking **OK** at the bottom of the dialog, results in carrying out the modifications and closing the dialog. Select **Cancel** to discard the modifications entered in the dialog.

General

The first option under the General tab controls the size of the fonts used in the GUI at start-up (**GUI Start-Up Font Size**).



For example, increasing the **GUI Start-Up Font Size** to 14 results in the display of a larger font overall in the GUI after restarting GeoDict.



GeoDict automatically stores a copy of the previous 3D structure, before applying any changes to it, until the **Memory for Undo** is filled up. This allows to quickly undo any changes using the undo function:

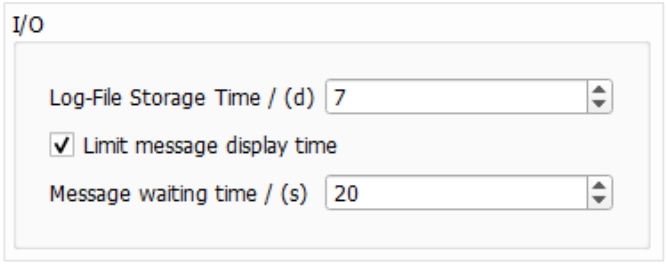
Disadvantage of keeping a copy of the last structure is that some runtime and hard disk space is required for saving the structures. Thus, it can be disabled by setting the **Memory for Undo** to 0 MiB.

If **Check for GeoDict Updates** is checked, GeoDict will automatically search (requires internet connection) if updates are available and print a message if an update is found.

GeoDict will not automatically download or install those updates.

In the corresponding panels underneath are the options for disk usage (**I/O**), and for setting a default **Text Editor**.

I/O

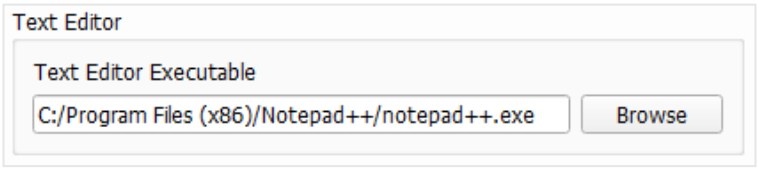


In the **I/O** (input/output) options, define how many days the log files, in which the events happening while running GeoDict are recorded, should be kept.

Also define whether the time a warning message is displayed should be limited, and the time of the limitation in seconds. If 0 is selected, pop-up messages are not shown at all.

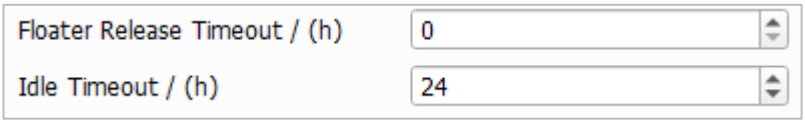
Text Editor

The user can set which text editor is to be opened automatically when editing macros and other editable files. Click **Browse** to search and set the path to the location where the executable for the favorite text editor is located.



Timeout options

The last two options are for floating license users only. Define after how many hours the **Floater Release Timeout** will be triggered. Then all non-required floaters are freed and are available for other users. This is especially useful if long-running computations are performed. The same behavior occurs when pressing the **Release Floaters** button in the progress bar during a simulation run.

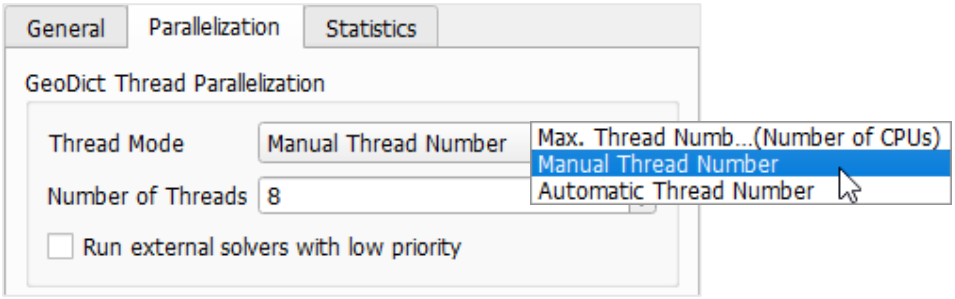


The **Idle Timeout** triggers if after the defined hours no computation or user interaction was made. Then all floaters, including also the GeoDict -Base floater, are freed and available for other users. It is possible to re-acquire the freed floaters when returning to the GeoDict application in the then opening dialog.

PARALLELIZATION

GeoDict Thread Parallelization

The user can set the number of parallel processes (threads) GeoDict should use, e.g., for the visualization, for the image processing, and for the structure generation. It is possible to set the Thread Mode to **Max. Thread Number** which equals the **Number of CPUs** the machine has. When not all available CPUs of the computer should be used, perhaps to allow other users to work simultaneously on the same machine or to improve the running of other programs, the number of used parallel processes can be limited by setting a **Manual Thread Number**.



Choosing **Automatic Thread Number** uses the maximum number, if up to eight cores are available. If more than 8 cores are available, the maximum of 8 and the number of available cores divided by two is used.

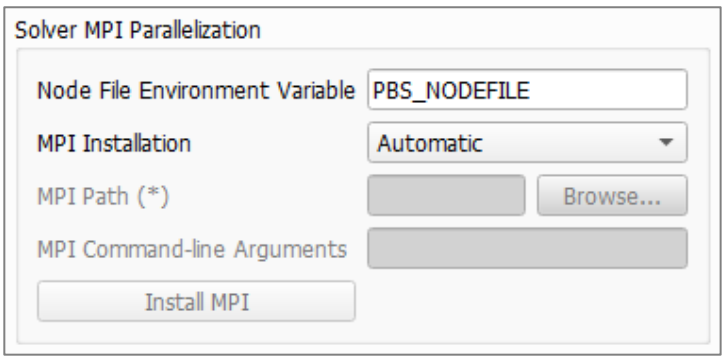
This option has nothing to do with the solver processes, which can be set for all GeoDict solvers in the Dict modules independently.

Check **Run external solvers with low priority** to make the system more responsive when working interactively while a GeoDict solver (e.g. LIR or SimpleFFT) is running.

Solver MPI Parallelization

For cluster computations, set the environment variable that holds the location of the node file, i.e., the file that contains the list of assigned compute nodes.

For MPI parallel computations, set the path to the **MPI Installation** that should be used for the parallelization. Select **Automatic** to look automatically for MPI installations.



For more information, refer to the High Performance Computing handbook of this User Guide.

STATISTICS

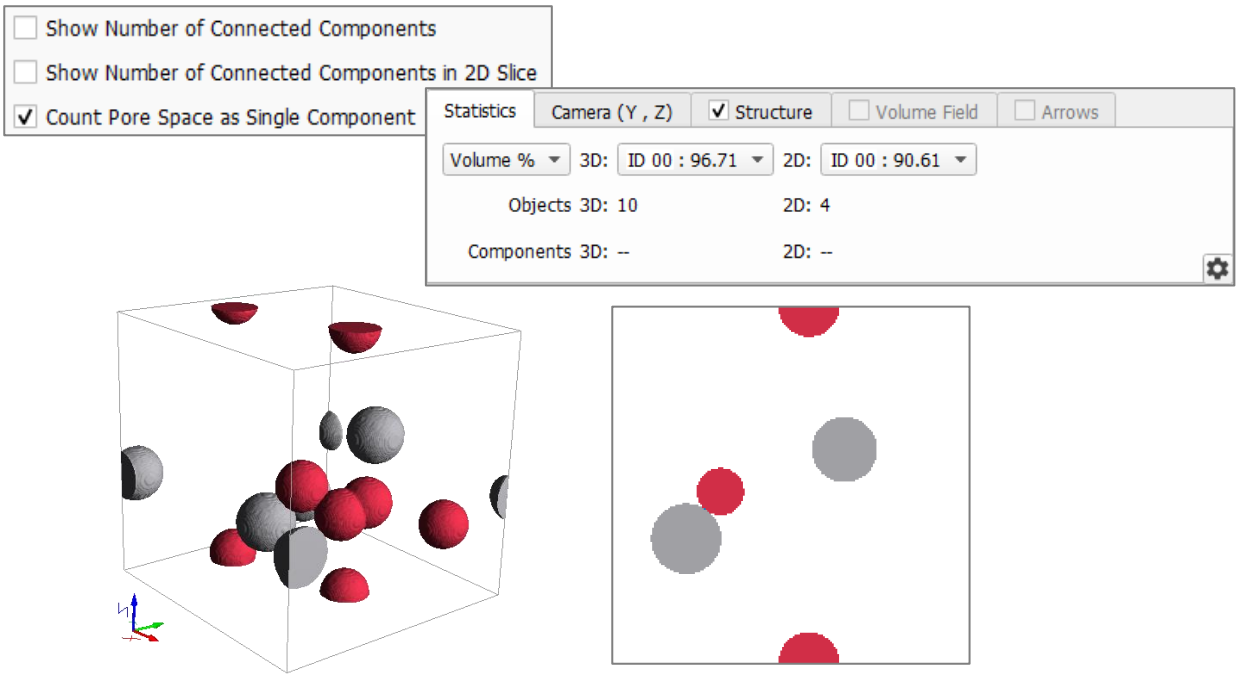
The **Connected Components** panel is found under the Statistics tab. A connected component is defined as a complete set of color voxels.

Checking **Show Number of Connected Components** or **Show Number of Connected Components in 2D Slice**, and clicking **OK**, adds the number of **Components 3D** and **Components 2D** to the **Statistics** tab in the Visualization panel above the Visualization area.

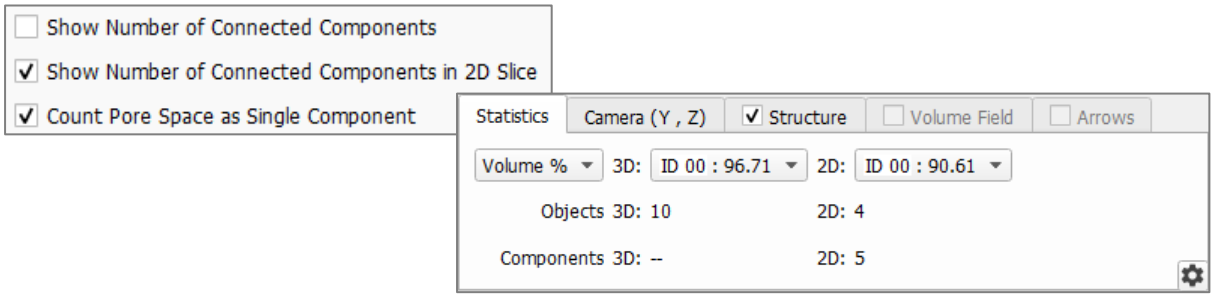
If the pore space is divided by the structure into several parts it can, with **Count Pore Space as Single Component** checked, be counted as one connected component. The pore space does not count as an object and does not add to the number of **Objects**.

As example, a simple periodic structure model contains 10 spheres. At the corners, it is the same grey sphere that disappears and reappears on the other side. Two red spheres are also cut in half. They disappear and reappear in Z-direction. Three of the red spheres overlap and one of the red spheres touches a grey sphere.

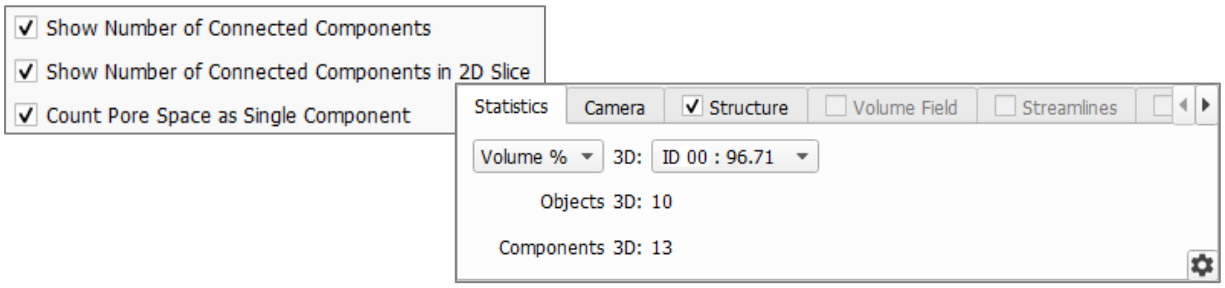
The number of **Objects 3D** is 10, but the number of **Objects 2D** is only 4 (2 grey and 2 red spheres) in the 2D-Slice 126 (move the slider under the Camera (Y,Z) tab). The pore space is not counted as object.



Now, see how the connected components in 2D are counted when checking **Show Number of Connected Components in 2D Slice**. The number of Objects 3D and 2D are the same as before. For **Show Number of Connected Components in 2D Slice**, the pore space and the red-grey touching spheres are each counted as a connected component. Connected components in 2D are 5 (1 grey sphere + 1 partial red sphere (top) + 1 partial red sphere (bottom) + 1 [1 red sphere+1 grey sphere] component + 1 pore space).



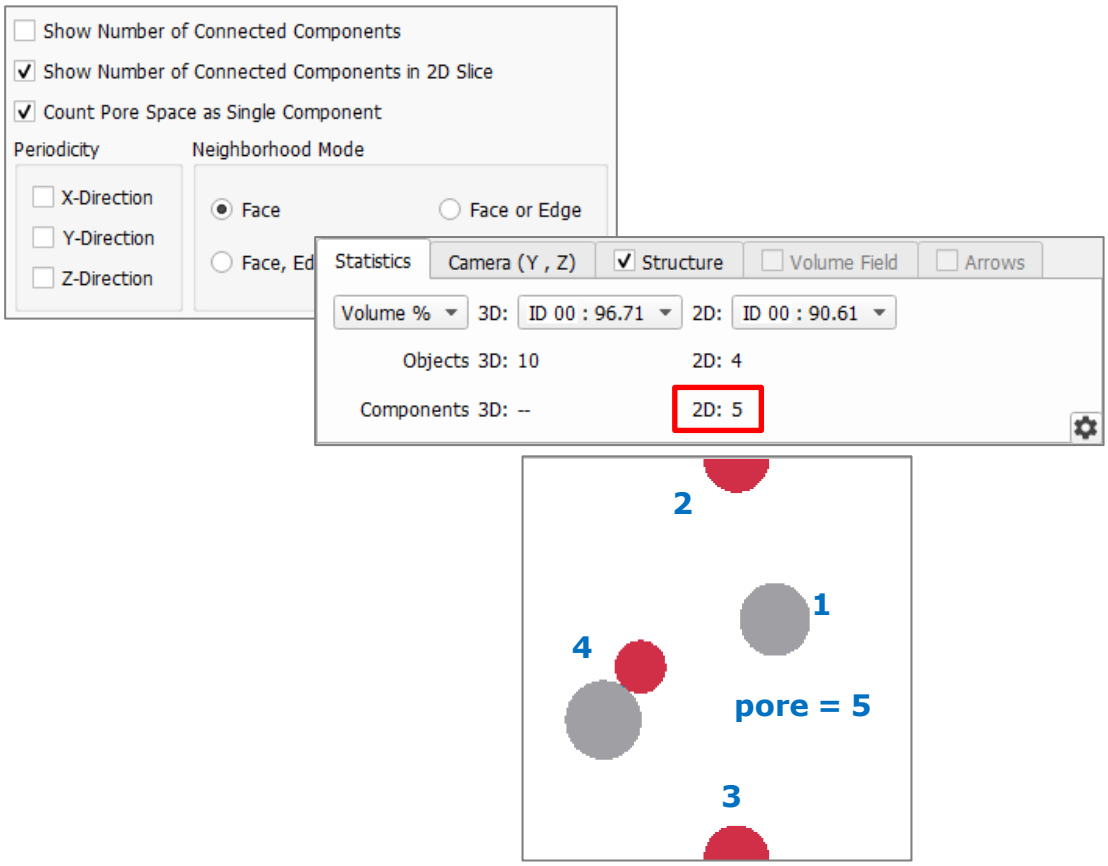
Next, **Show number of Connected Components** is checked and they are counted in 3D. Connected components in 3D are 13 (2 grey spheres + 4 partial grey spheres + 1 red sphere + 4 partial red spheres + 1 [3 red spheres+1 grey sphere] component + pore space).



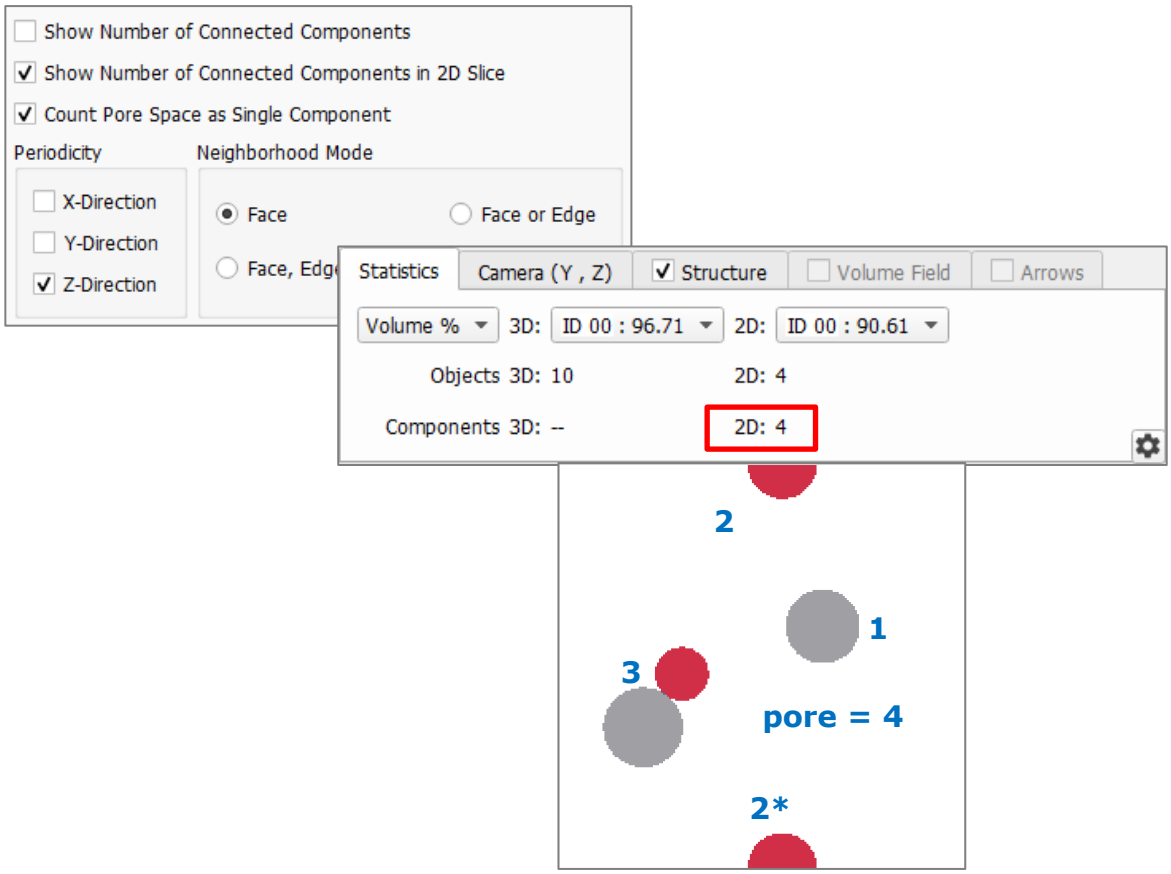
Periodicity, **Neighborhood Mode**, and **Component Mode** define criteria for the connectivity of the components.

For periodic structures, checking **Periodicity** in **X-Direction**, **Y-Direction**, or **Z-Direction** affects the number of connected components. Objects that end on one side of the volume and reappear on the opposite side are counted as being the same connected component, decreasing the final number of connected components.

For example, the structure shown above is periodic in Z-direction, and without checking periodicity, 5 connected components in 2D are counted (#1 grey sphere + #2 partial red sphere (top) + #3 partial red sphere (bottom) + #4 [1 red sphere+1 grey sphere] component + #5 pore).



Next, checking **Periodicity** in **Z-Direction** decreases the number of connected **Components 2D** to 4, because the red sphere at the edge of the domain reappears at the opposite edge and is then considered the same connected component.

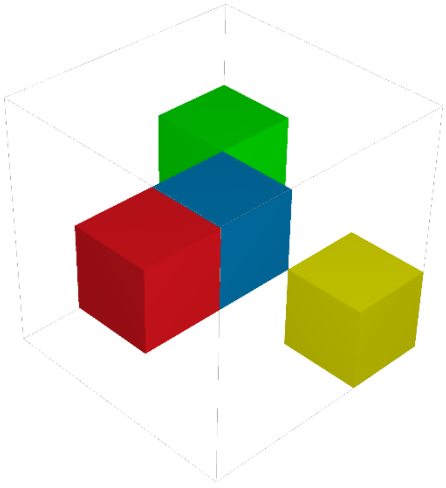


The 4 connected components are: (#1 grey sphere + #2 red sphere (top+bottom) + #3 [1 red sphere+1 grey sphere] component + #4 pore). The number of **Objects** does not change, and the same four objects are detected in 2D. The pore space is not counted in the number of **Objects**.

Neighborhood Mode

Neighboring structure components can be connected through faces, edges, and corners of voxels, i.e., two voxels of the same color that share a corner point always belong to the same connected component.

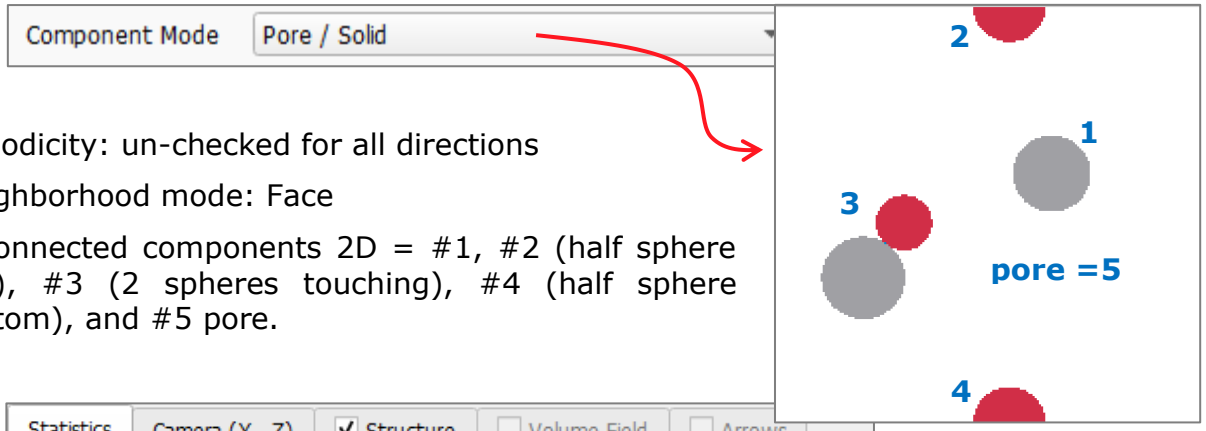
Checking **Face** is more restrictive than choosing **Face or Edge**, and this is more limiting than selecting **Face, Edge or Corner**.



The Neighborhood Modes are explained using the example on the right. When choosing the Neighborhood Mode **Face** only the red and the blue voxel are neighboring (they also share edges and corners). When choosing **Face or Edge** the red and the blue voxel and the blue and the green voxel (they also share corners) are neighboring. Finally, if **Face, Edge or Corner** is chosen the red and the blue voxel, the blue and the green voxel and the blue and the yellow voxel are neighboring.

Component Mode

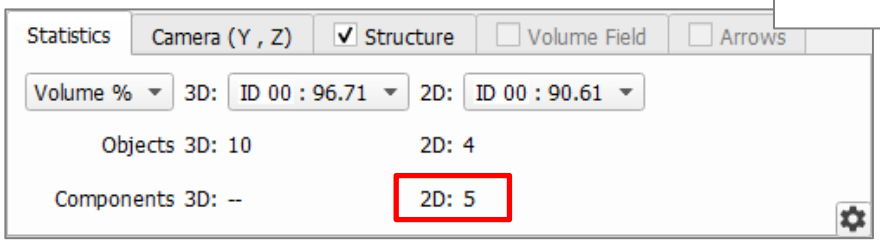
For structures with more than one material, selecting **Pore / Solid** from the **Component Mode** pull-down menu determines whether the components are considered connected or not, based on being empty voxels (background) or solid voxels (structure), regardless of their color. When selecting **Material ID**, the Material ID (color) of the solid voxels (structure) is determinant for the components to be considered connected or disconnected.

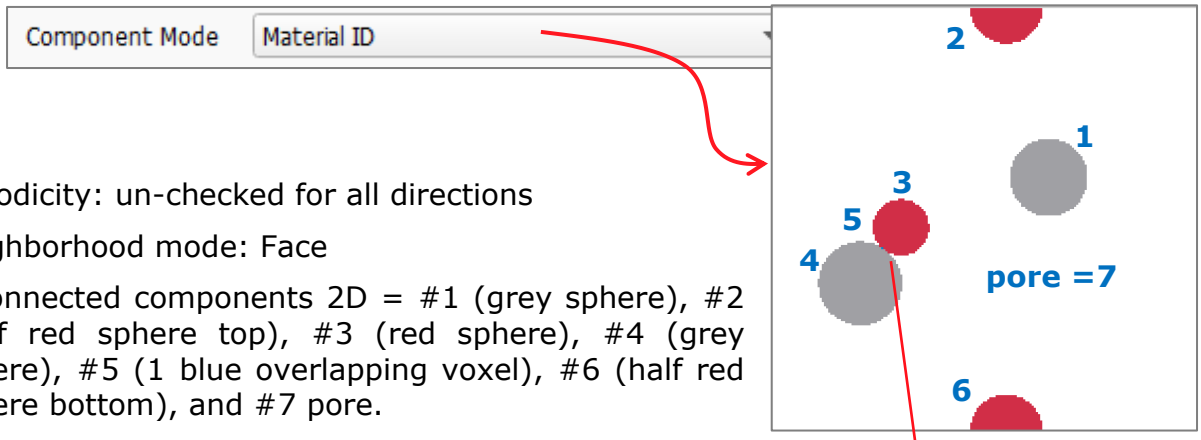


Periodicity: un-checked for all directions

Neighborhood mode: Face

5 connected components 2D = #1, #2 (half sphere top), #3 (2 spheres touching), #4 (half sphere bottom), and #5 pore.

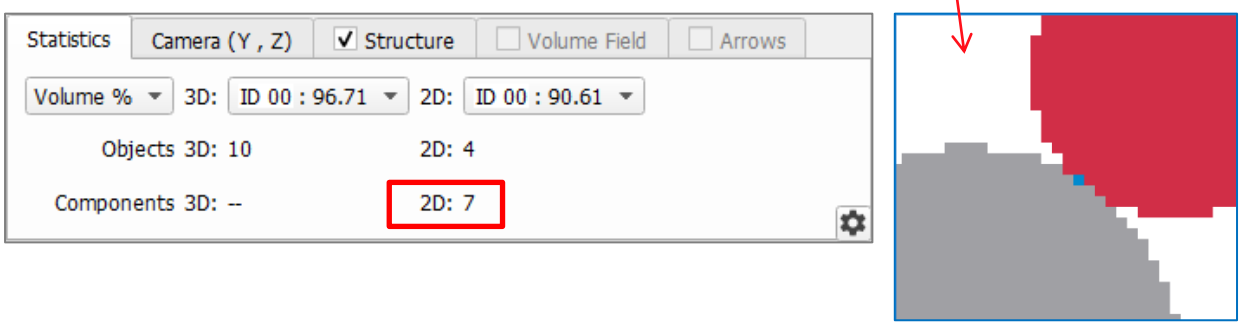




Periodicity: un-checked for all directions

Neighborhood mode: Face

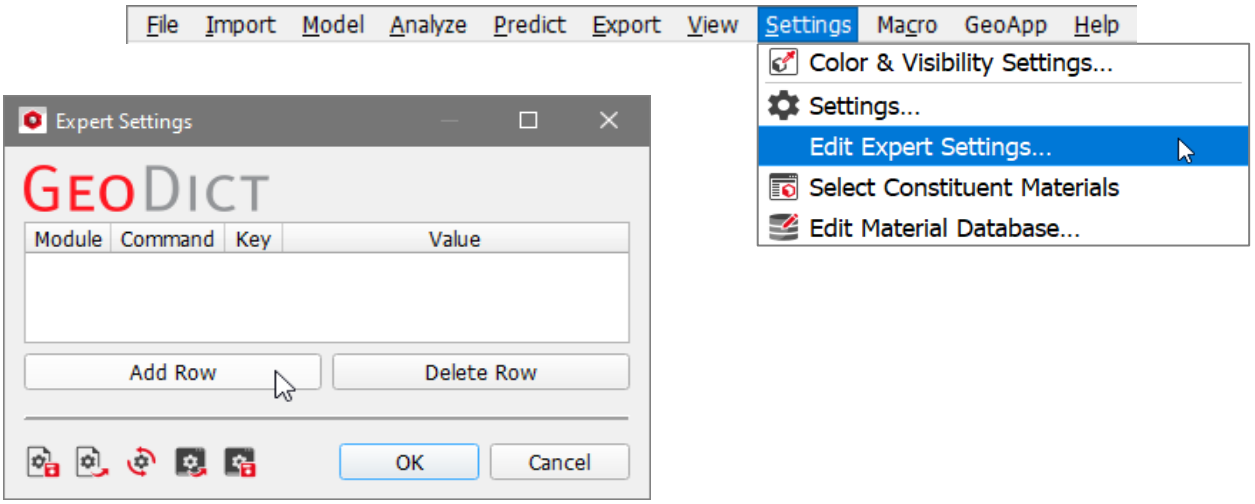
7 connected components 2D = #1 (grey sphere), #2 (half red sphere top), #3 (red sphere), #4 (grey sphere), #5 (1 blue overlapping voxel), #6 (half red sphere bottom), and #7 pore.



Edit Expert Settings...

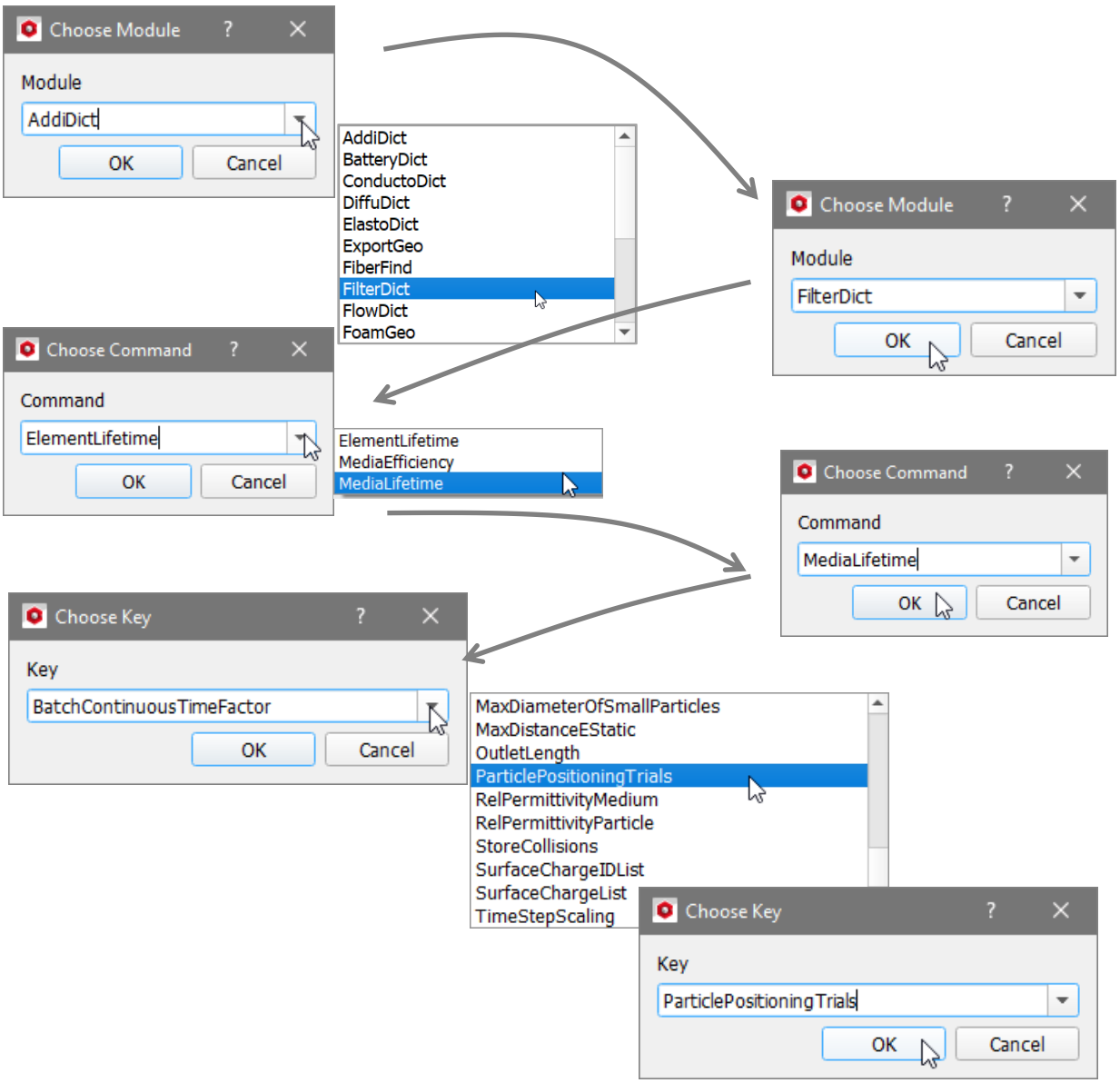
For many commands available in GeoDict's modules, additional parameters exist that are not available through the dialog widgets that open in the corresponding modules. These parameters are also not stored in the parameter lists of those commands inside the python macros. By default, no expert settings are set, and well-chosen default values are used.

Some expert settings allow to access experimental or unstable features. Others allow to access solver variants that are only useful in very special circumstances. In general, a user should not set any expert settings without consultation of Math2Market's support.

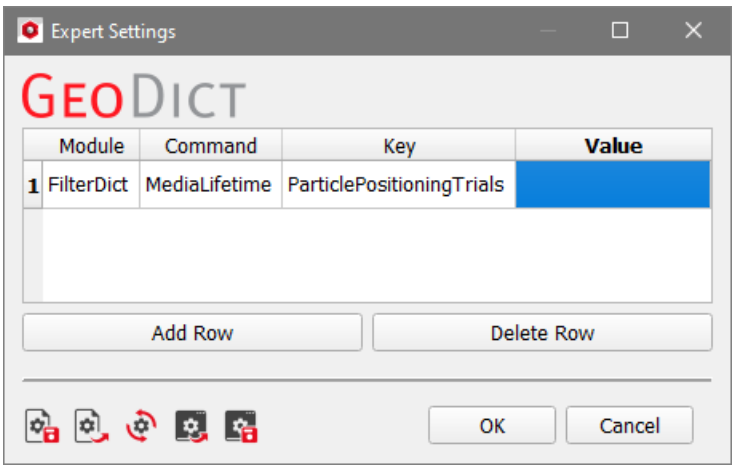


To activate an expert setting, after selecting **Edit Expert Settings...**, the user clicks **Add Row** to sequentially select the **Module**, the **Command**, and the **Key** that define the expert setting that should be edited.

Clicking **OK** at the bottom of the dialog, results in carrying out the modifications and closing the dialog. Select **Cancel** to discard the modifications entered in the dialog.

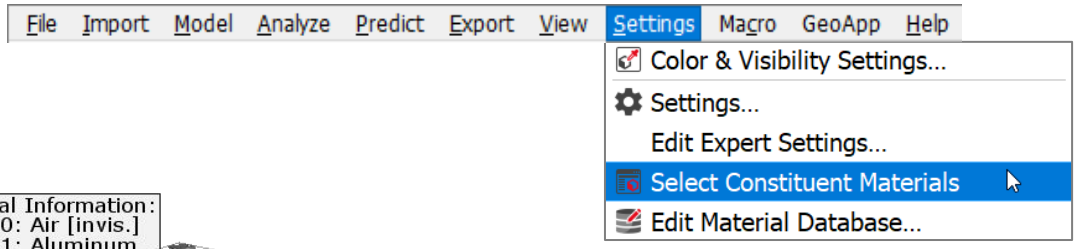


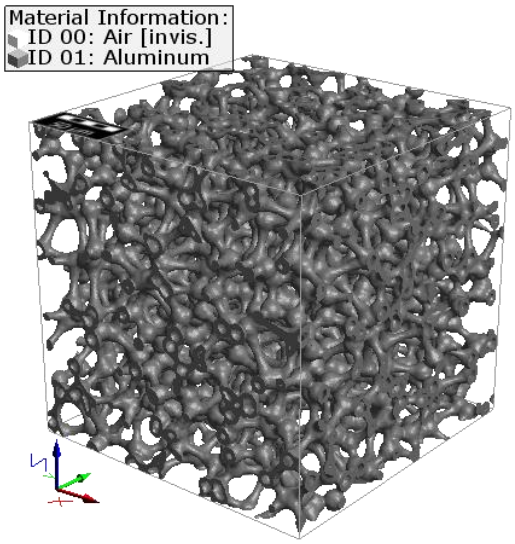
The choices of module, command, and key are entered as columns into the first row. The user can now click the cell under **Value** and manually enter it.



Select Constituent Materials

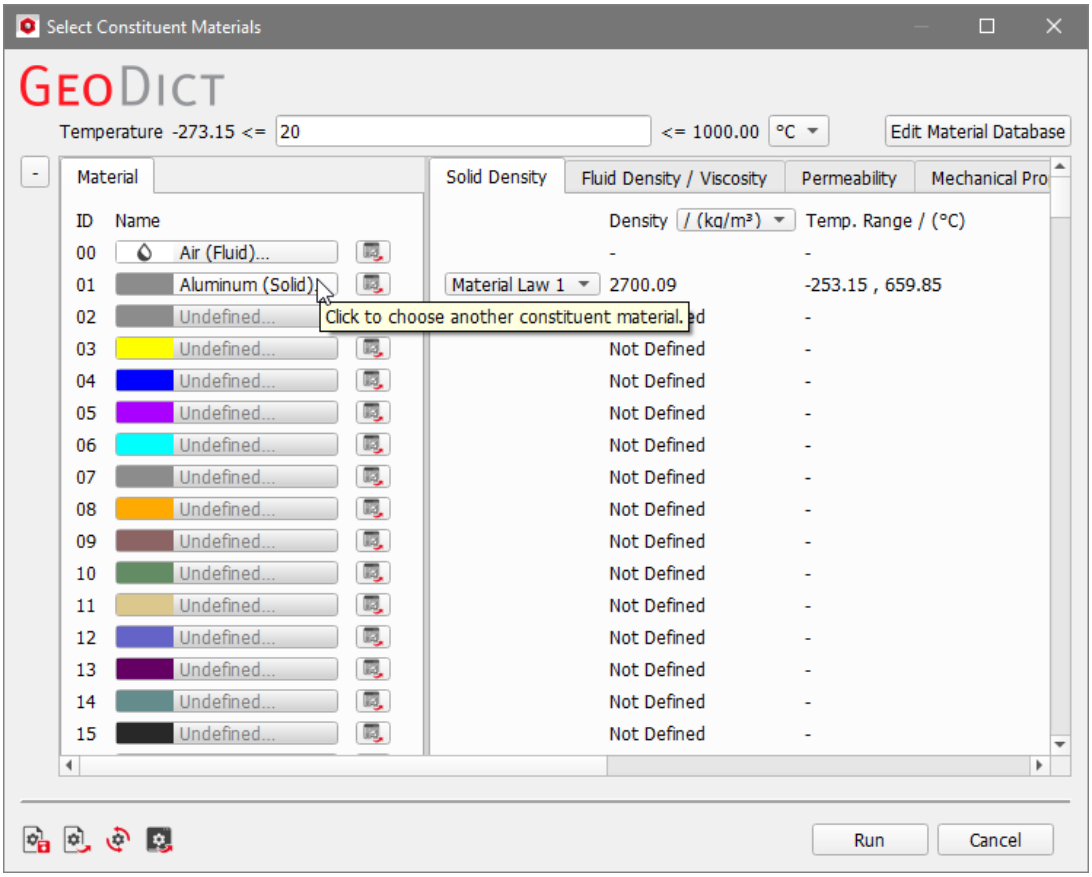
A Constituent Material from the Material Database consists of a name for the raw material and the material's physical properties and represents the properties of a material in a structure model.

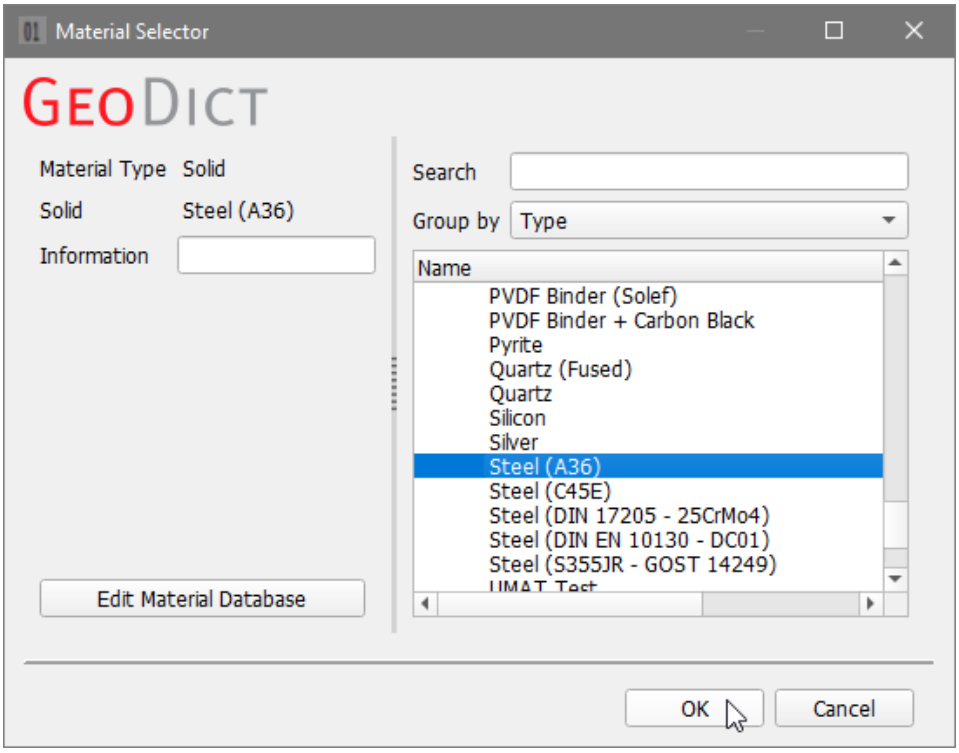




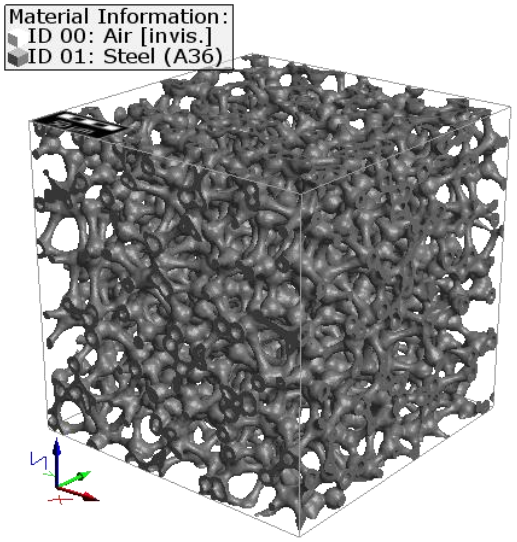
With a structure model in memory, showing in the Visualization area, select **Settings → Select Constituent Materials** to change the raw material of a Material ID or assign a material to a Material ID with undefined material in a structure model.

For example, in a foam structure the Material ID 01, initially defined as Aluminum, can be changed to be made of Steel as follows:





If the new material is selected, close the dialog by clicking **OK** in the Material Selector dialog and **Run** in the Select Constituent Materials dialog.

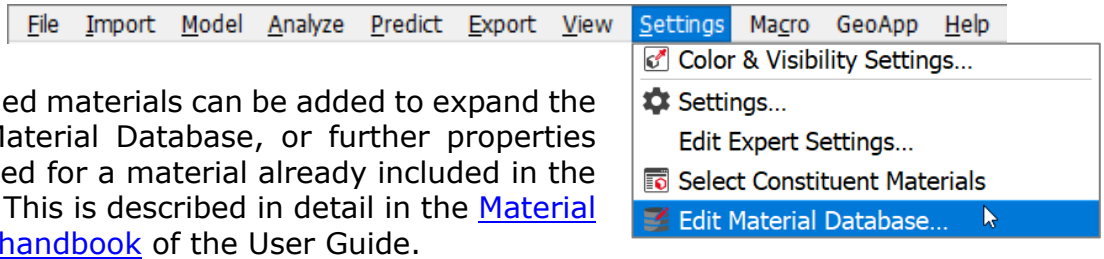


EDIT MATERIAL DATA BASE...

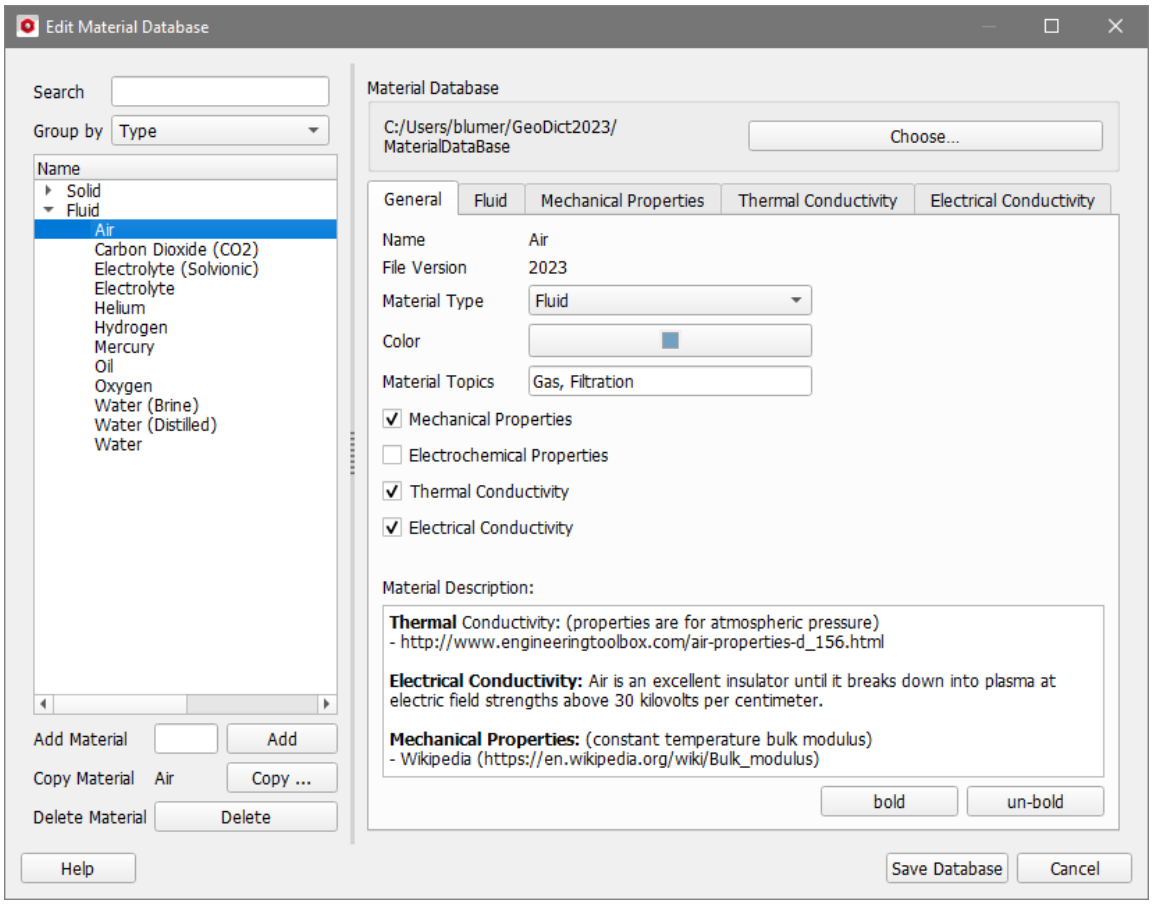
In GeoDict, constituent materials (and their physical properties) are **globally assigned to a structure** and not just to a property predictor simulation.

The GeoDict Material Database is a catalogue of the constituent materials that can be assigned to correctly identify digital materials in the structure models with properties of real materials.

The user can access and edit the GeoDict Material Database from many modules or select **Settings → Edit Material Database...** to directly access the catalogue from the menu bar.



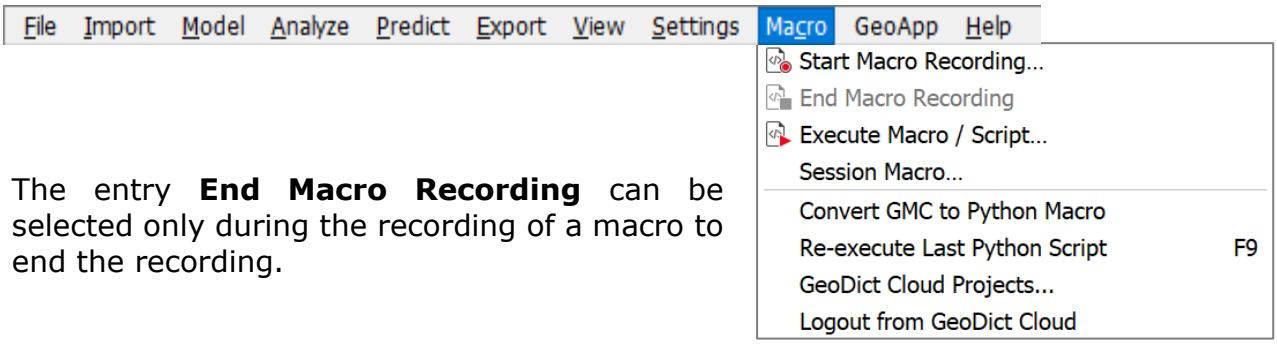
User-defined materials can be added to expand the GeoDict Material Database, or further properties can be listed for a material already included in the database. This is described in detail in the Material Database handbook of the User Guide.



Each material in the database, together with its properties and description, is saved as a text-file with the name of the material. The user can edit these files in any text editor. The default GeoDict Material Database is located at:

MACRO

The Macro menu contains the entries **Start Macro Recording**, **End Macro Recording**, **Execute Macro / Script**, and **Session Macro**.

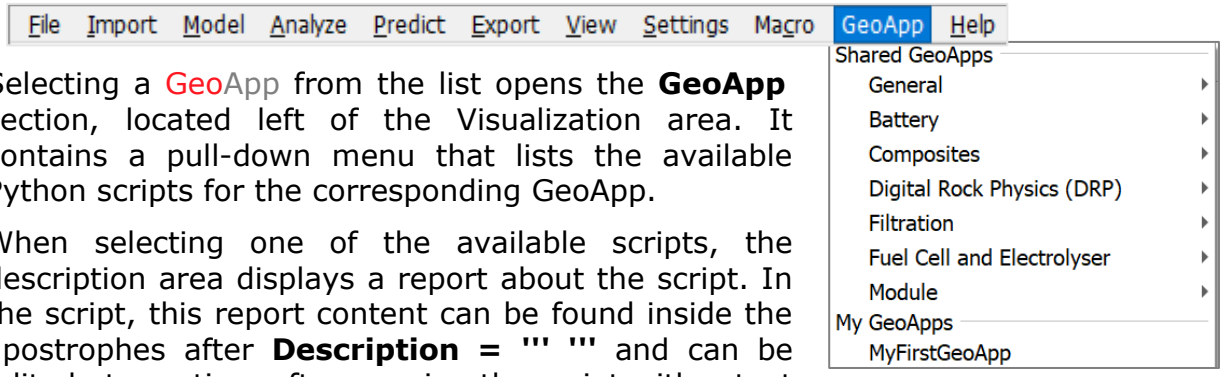


The entry **End Macro Recording** can be selected only during the recording of a macro to end the recording.

Macro recording and execution and the options **Convert GMC to Python Macro**, **Re-execute Last Python Script** and **GeoDict Cloud Projects** are explained in detail in the Automation by scripting handbook of the User Guide.

GeoApp

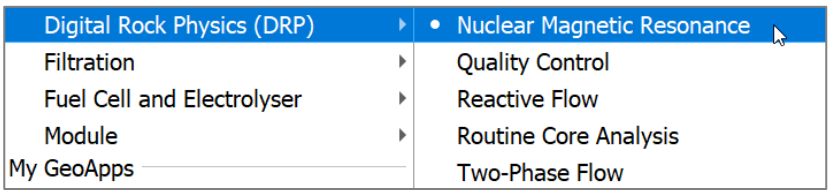
When selecting **GeoApp** in the menu bar a pull-down menu of GeoApps opens. The **Shared GeoApps** are apps delivered with GeoDict and apps the users create and share with their colleagues. Under **MyGeoApps** find an example GeoApp and the local GeoApps created by the user and placed in the GeoDict settings folder. The individual GeoApps are sorted by their application fields or the module they belong to.

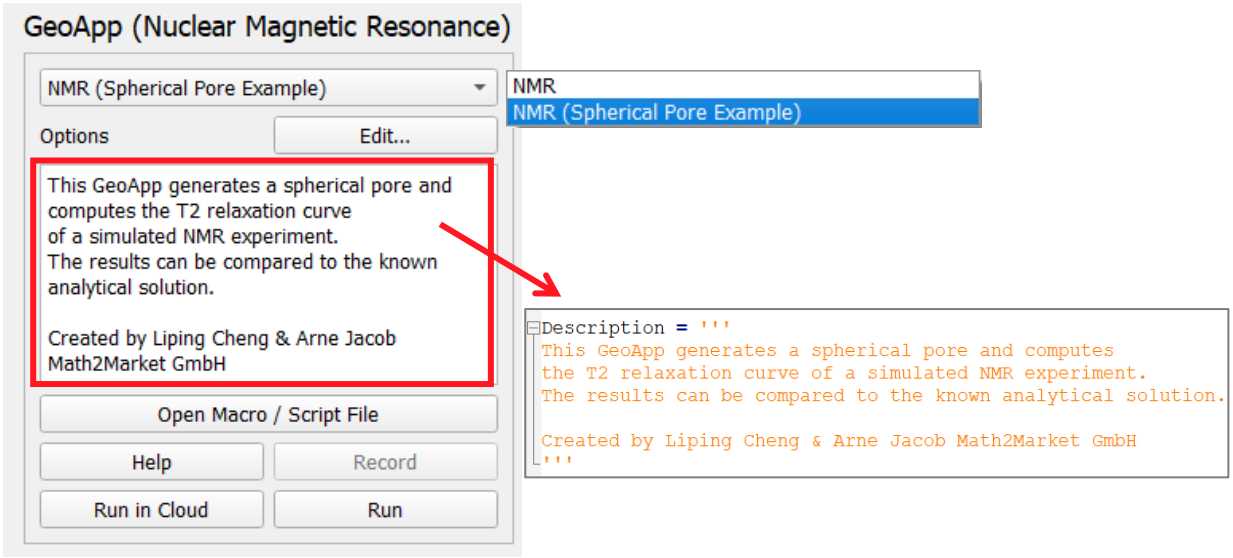


Selecting a GeoApp from the list opens the **GeoApp** section, located left of the Visualization area. It contains a pull-down menu that lists the available Python scripts for the corresponding GeoApp.

When selecting one of the available scripts, the description area displays a report about the script. In the script, this report content can be found inside the apostrophes after **Description = ''' '''** and can be edited at any time after opening the script with a text editor.

For the **NMR (Spherical Pore)** script from the **Digital Rock Physics (DRP)** App, the text in the macro and the description area are shown here.





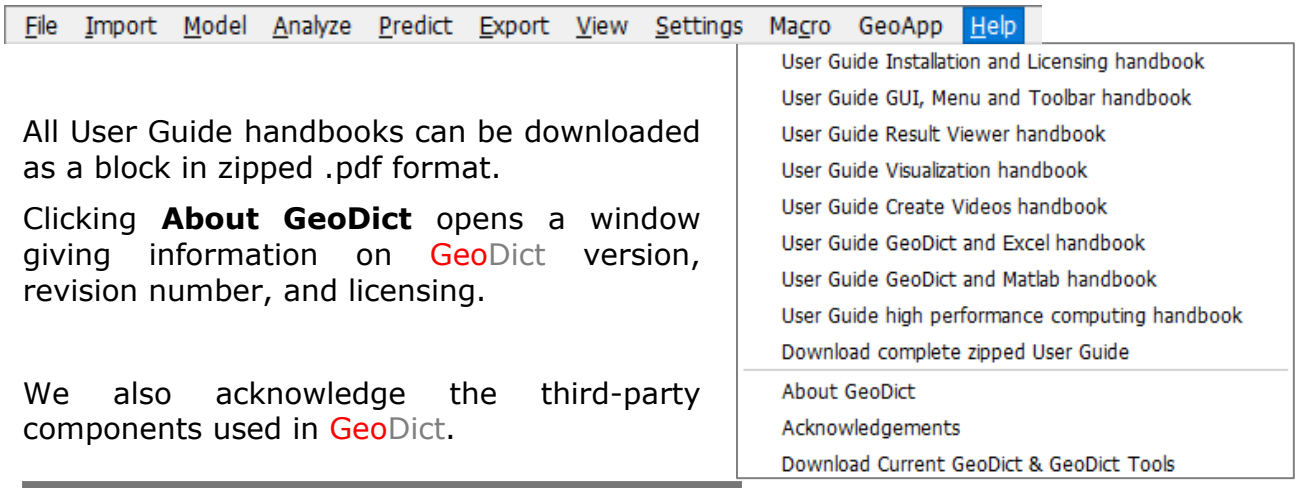
Click the Options' **Edit ...** button to edit the parameters of the macro. To open the GeoApp in an editor, click **Open Macro / Script File**. Clicking **Run** executes the script.

The GeoApp scripts listed in the pull-down menus can be found in the GeoDict installation folder in the subfolder GeoApp or in the subfolder of the corresponding module.

More details about using GeoApps can be found in the GeoApp handbook of this User Guide.

HELP

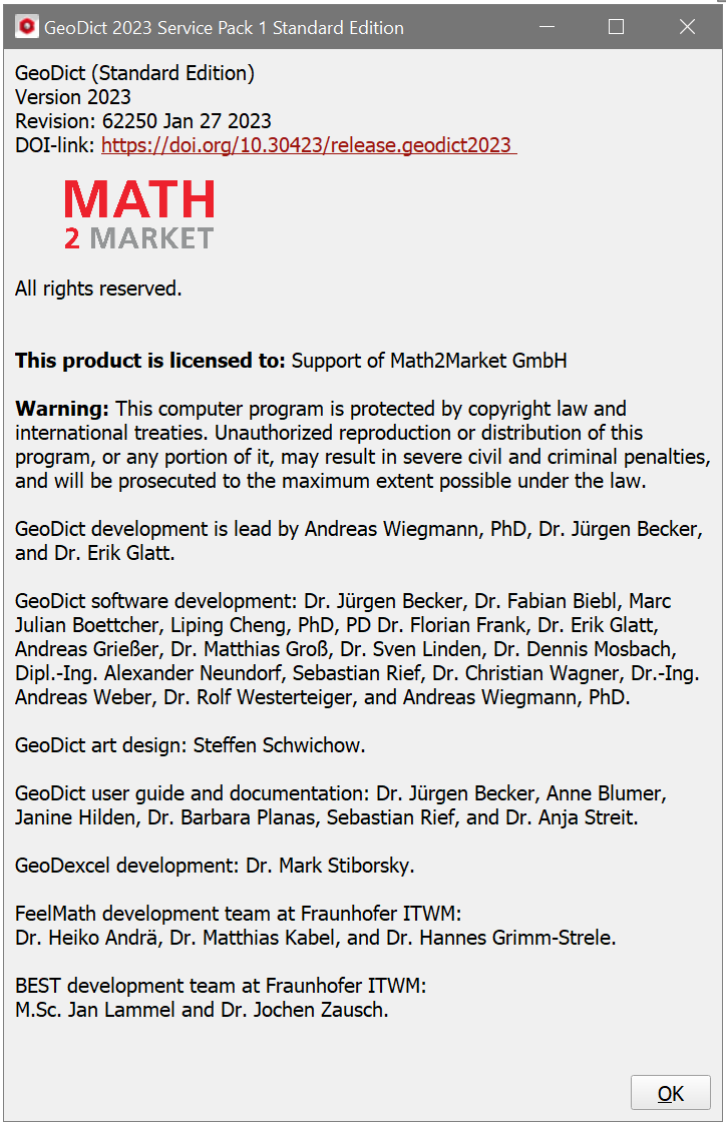
The **Help** menu links directly to several volumes of the User Guide on the GeoDict web page for information on installation and licensing of GeoDict, the introduction to the GUI, menu and toolbar, the Result Viewer for the result files, Visualization and video creation in GeoDict, using GeoDexcel and GeoLab and setting up high performance computing.



All User Guide handbooks can be downloaded as a block in zipped .pdf format.

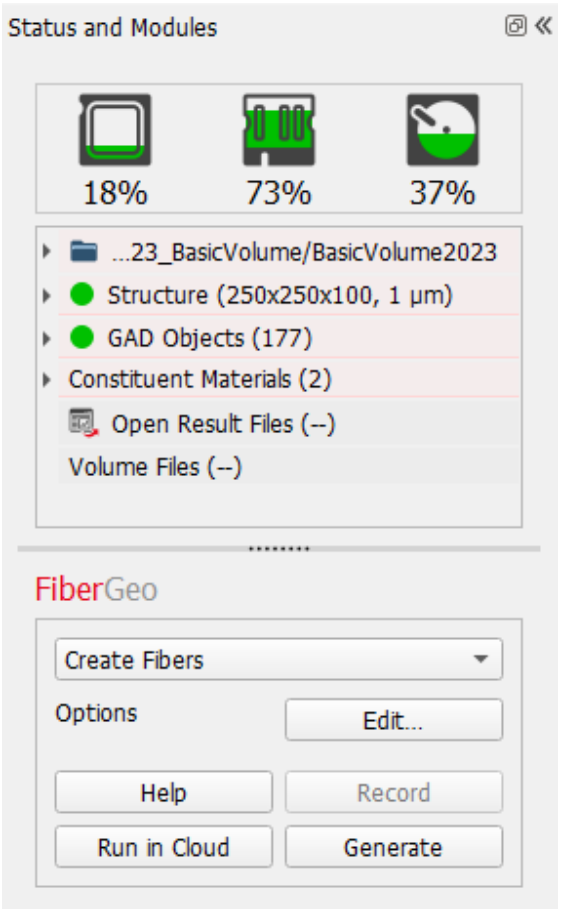
Clicking **About GeoDict** opens a window giving information on GeoDict version, revision number, and licensing.

We also acknowledge the third-party components used in GeoDict.



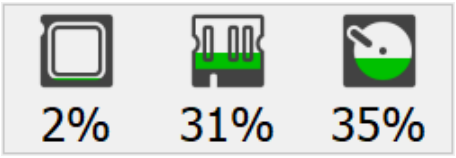
Status and Modules Section

The Status and Modules section is divided into the **Project Status Section** and the **Module Section**. It can be collapsed by clicking on the « icon or expanded in a new window by clicking on the icon.



Project Status Section

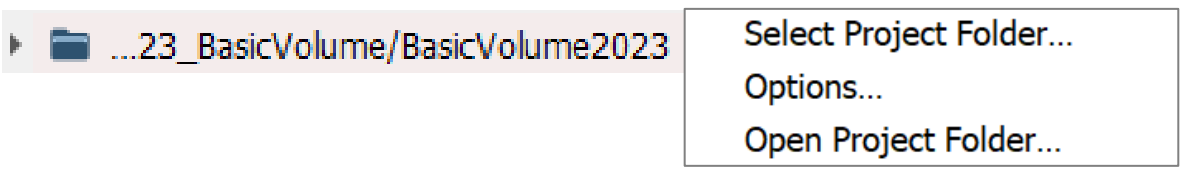
The **Project Status** section displays (from left to right) the current **CPU** load, the currently used **RAM** and the percentage of **Disk Space** used on the drive where the project folder is located. This refers to all processes running on the computer, not only to GeoDict.



Below, several information about the current project and the loaded files is shown.

Current Project Folder

First, the path of the **Current Project Folder** is given. This section can be expanded by clicking on the small triangle on the left or double clicking on the folder path. Then all GeoDict Result files (*.gdr) which are stored in the project folder are listed. Double clicking on a file name opens it directly in the Result Viewer.

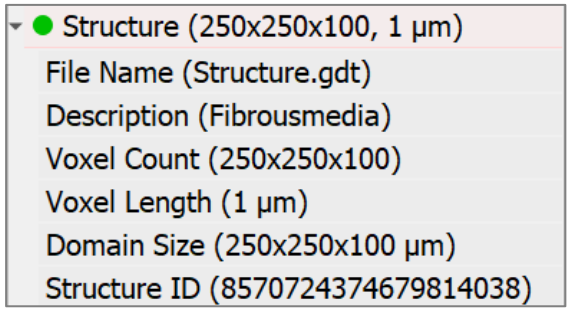


A right-click on the Current Project Folder row opens a menu used as shortcut for Choose Project Folder (see page 6 for details).

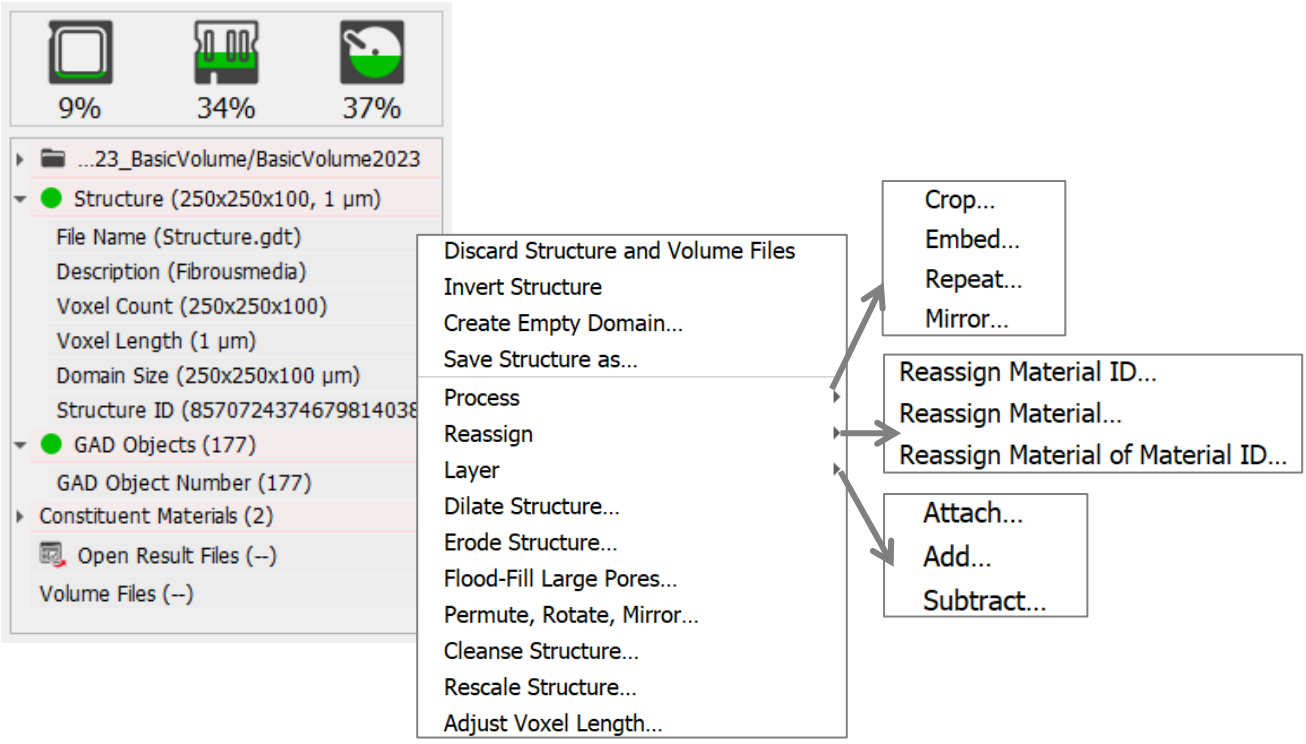
STRUCTURE

The color dot in front of **Structure** shows whether any voxelized structure is loaded into GeoDict (green dot), or not (red dot).

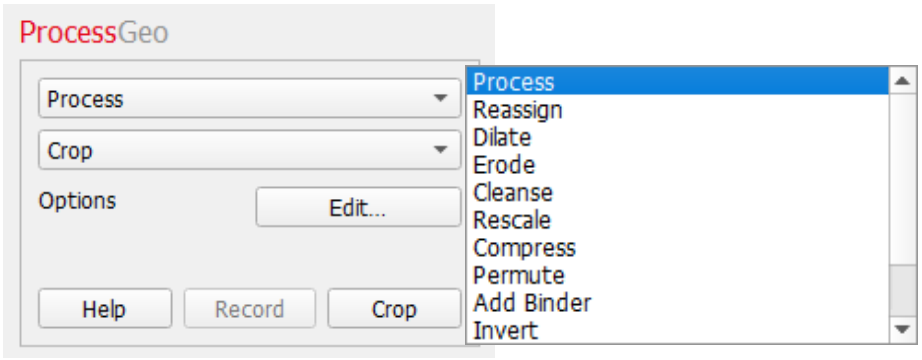
The **Structure** model is identified by File Name, Description, Voxel Count, Voxel Length, Domain Size and the internally hashed **Structure ID** number. A structure generated, e.g., with FiberGeo, GrainGeo, PaperGeo, WeaveGeo, GridGeo, or PleatGeo, with the same parameters and the same random seed, has always the same **Structure ID** number. The **Structure ID** number changes as soon as the structure is modified in any way.

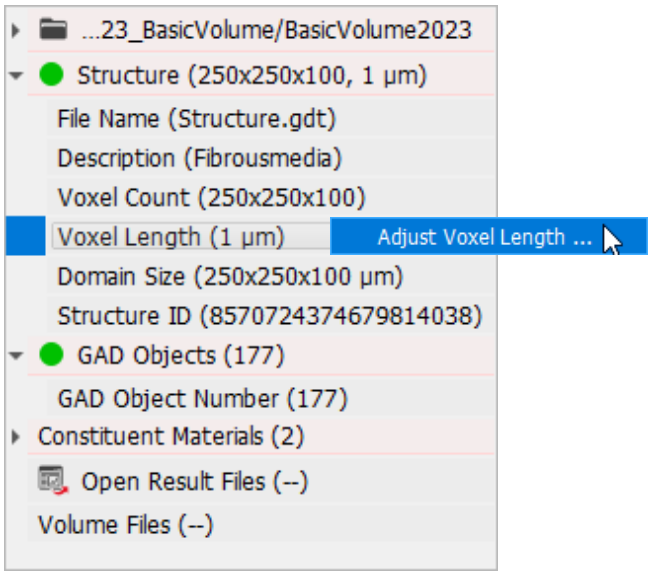


Right-clicking on the **Structure** row opens a menu used as a shortcut to apply modifications to the microstructure.

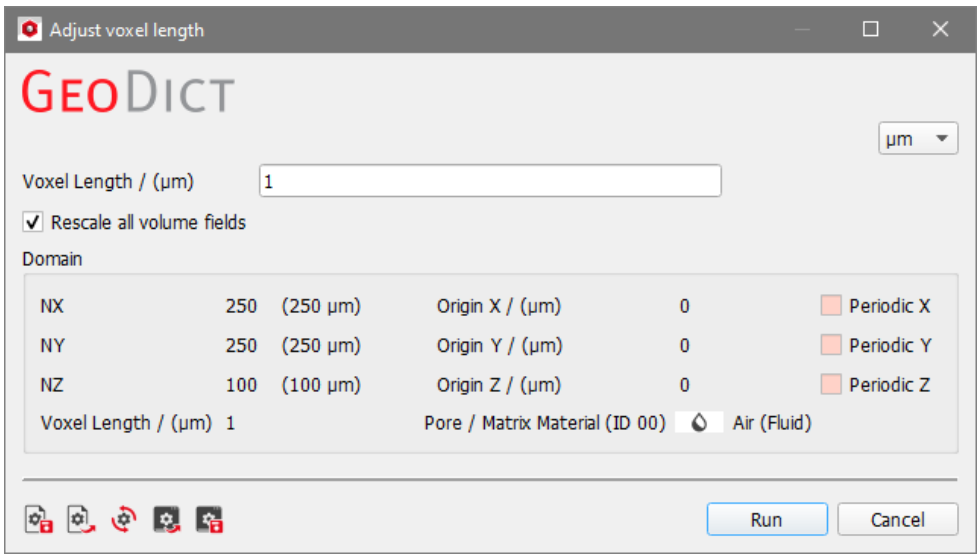


Most of the commands in this menu are shortcuts to several functions included under the **File** menu in the menu bar (see page 4 ff.), in the ProcessGeo module (Model → ProcessGeo, see also the ProcessGeo handbook), or in the LayerGeo module (Model → LayerGeo, see also the LayerGeo handbook).





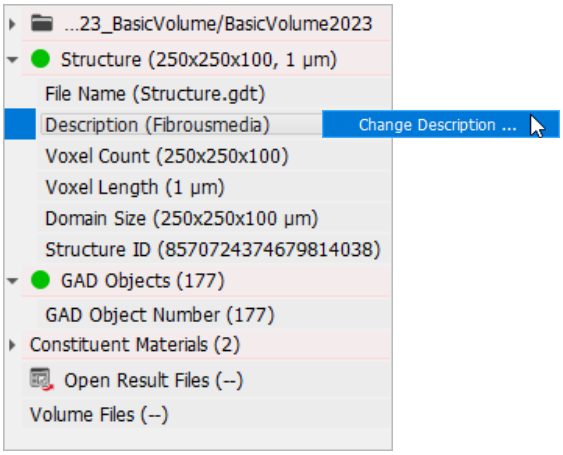
The **Adjust Voxel Length** command can also be accessed by right-clicking on **Voxel Length**, where the current voxel length is shown in the selected units (m, mm, µm, nm, Inch). This length can be adjusted by changing parameters in the opening **Adjust voxel length** dialog. Here, also the unit for the voxel length can be selected from the pull-down menu at the top right of the dialog. The option **Rescale all volume fields** allows to change the voxel length of the currently loaded volume fields accordingly. Thus, a structure and its volume field can still be shown simultaneously in the visualization area.



Attention! The values inside the volume field are not changed! Thus, the volume field might not fit to the structure anymore,, e.g. if a velocity field is loaded.

This change in voxel length occurs on the already generated structure (post-processing). To vary voxel length for the generation of a new structure (pre-processing), the value has to be changed through the **Create → Options - Edit**... button in the module section of the corresponding Geo module (FiberGeo, GrainGeo, WeaveGeo, etc.).

When right-clicking on **Description** the description of the structure can be changed.



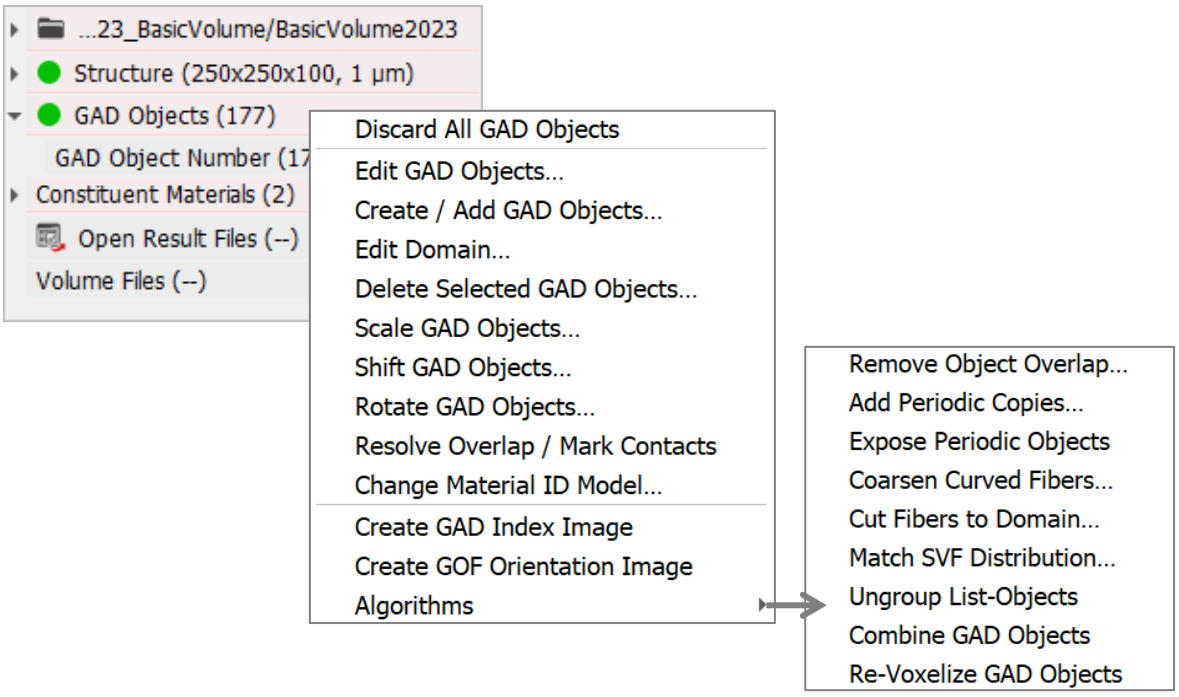
GAD Objects

The color dot in front of **GAD Objects** shows whether analytical information about the objects inside of the current structure is available (green dot), or not (red dot).

The dot is yellow when information about objects inside of the current structure is available, but this information does not describe the current structure completely. This may happen, for example, when the structure has been modified after the generation (e.g., with ProcessGeo or LayerGeo).

Also shown is the number of GAD objects (such as fibers, grains, etc.) in the structure (**GAD Object Number**).

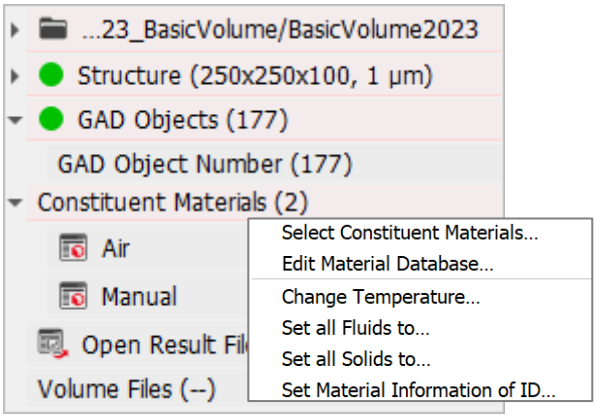
Right-clicking on **GAD Objects** opens a list of possible modifications, like editing the GAD objects or the domain, creating, adding, deleting, scaling, shifting and rotating GAD objects, resolve overlap and mark contacts, change the Material ID model, or to create a GAD index image or an orientation image. All of these modifications can be accessed also from the module GadGeo and are explained in the GadGeo handbook of the User Guide.

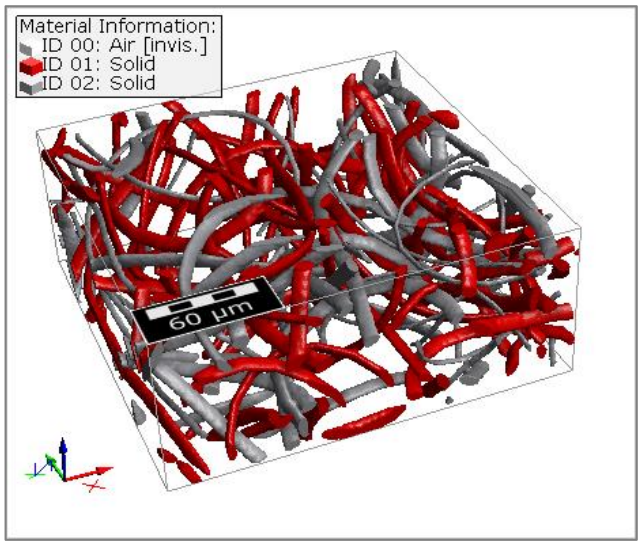


By choosing **Algorithms**, all manipulations of analytic objects, available in the section Algorithms of GadGeo can be accessed.

CONSTITUENT MATERIALS

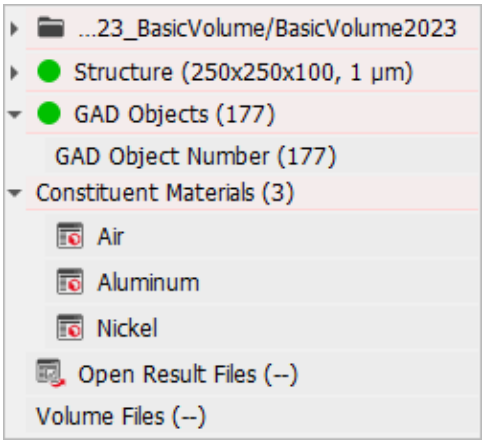
The next entry in the Project Status section is **Constituent Materials**. This block lists the materials that are present in the structure and are shown in the **Material Information** legend next to the microstructure in the Visualization area.



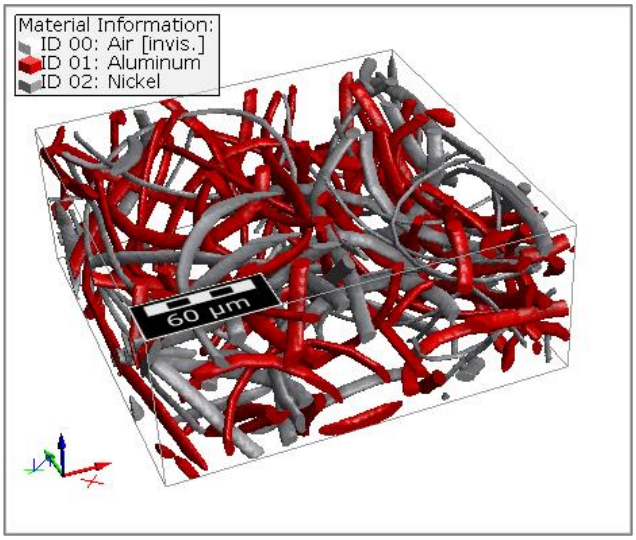


Right-clicking on **Constituent Materials** gives access to the **Select Constituent Materials** dialog and is a shortcut to selecting **Settings → Select Constituent Materials** in the menu bar. **Edit Material Database** is a shortcut to **Settings → Edit Material Database**. The current temperature can be edited in the constituent materials dialog and also by clicking on **Change Temperature** , which opens a separate dialog. It is also possible to **Set all Fluids to** one chosen material and the same can be done for solids by clicking **Set all Solids to**. One can also **Set Material Information** for any Material ID.

In the example shown here, two **Constituent Materials** are listed in the **Project Status** section (Air and Manual), corresponding to *Air* and *Solid* in the **Material Information** legend. The fibers with material ID 01 and material ID 02 are set to be made of the same constituent material.



After changing the constituent material for material ID 01 to Aluminum and material ID 02 to Nickel, the number of **Constituent Materials** in the **Project Status** section changes from (2) to (3).

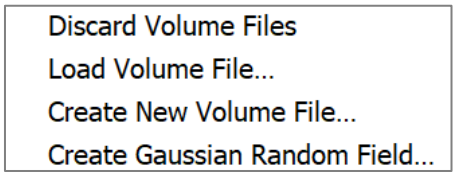


Open Result Files

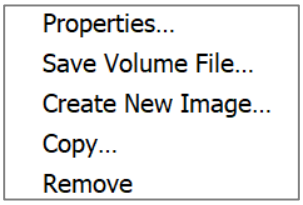
Open Result Files shows the number and names of result files that are currently opened in the **Result Viewer**.

Volume Files

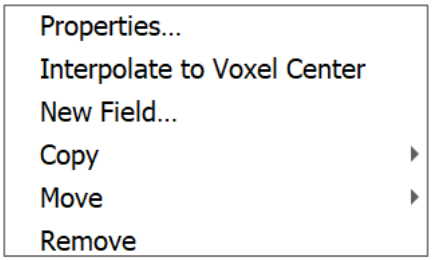
The last entry in the **Project Status** section is **Volume Files**. After loading a result file and a corresponding volume file (e.g., after an effective stiffness simulation with ElastoDict-FeelMath-VOX), the name of the result file (**Open Result Files**) and the corresponding **Volume Files** appear in the **Project Status** section. Each of the volume files consists of volume images and they contain several volume fields. In the example shown here the volume file StrainStressResult_xy.das is loaded. It has the volume images vonMisesStrain and vonMisesStress, and they contain a volume field with the same name, respectively. Double clicking on a volume field loads it into GeoDict and it can be seen in the Visualization area.



Right-clicking on Volume Files opens a list of options. Discard and Load Volume File are the same as those from the **File** menu in the menu bar (see page 4 ff.). It is also possible to **Create New Volume File**s or to **Create a Gaussian Random Field**.

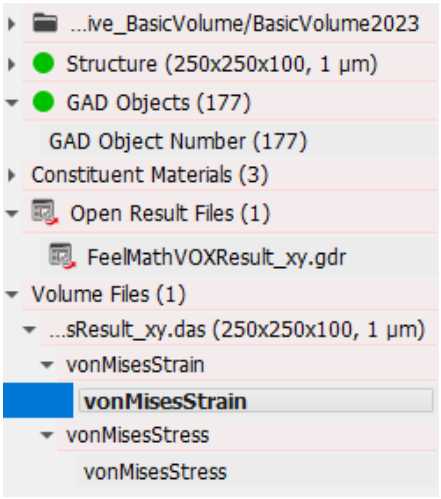


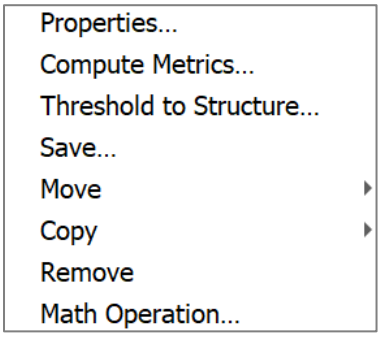
A right click on a loaded volume file provides further options. Choose **Properties** to get information on the volume file loaded. This volume file can also be **saved** in the current project folder. With **Create New Image** two types of images can be created. If **Scalar** is chosen, an empty volume image is created and a new volume field can be created as shown below. If **Vector** is chosen a volume image with 3 volume fields (containing only zeros) is generated and also the norm is automatically computed and shown.



Right-clicking on a volume image opens further options. Choose **Properties** to get information on the volume image and to change its name. The function **Interpolate to Voxel Center** interpolates the data to the voxel centers using the values on edges and faces of the voxels. If several volume files are opened it is possible to **Copy** or to **Move** a volume image into another volume file. With **Remove** a volume image can be deleted from the GeoDict memory. It is not deleted from the volume file saved in the project folder.

Finally, a right click on a volume field provides other possibilities, besides **Properties**, **Save** as .guf file, **Move** or **Copy** the field to another volume image, and **Remove** from memory, which are explained below.



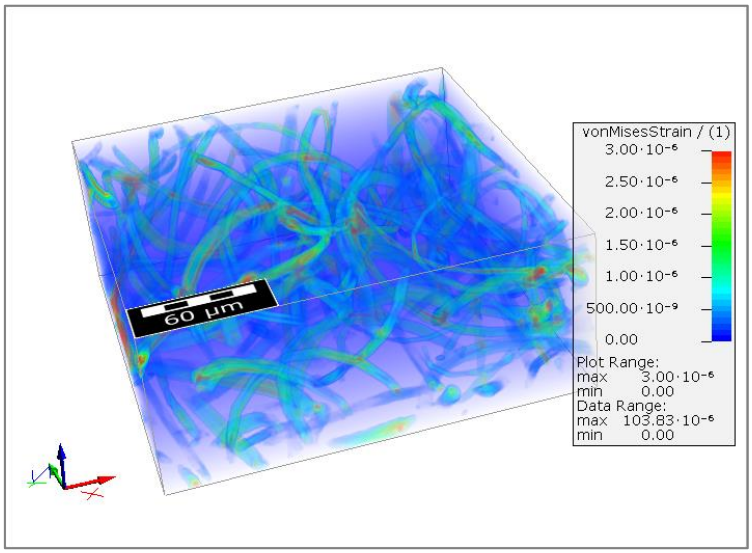


Compute Metrics

With **Compute Metrics**, access statistical properties of the volume field.

Enter a **Result File Name (*.gdr)** to save the results in. Then select on which of the loaded **Volume Field**s the properties should be computed.

Choose which metrics should be computed.

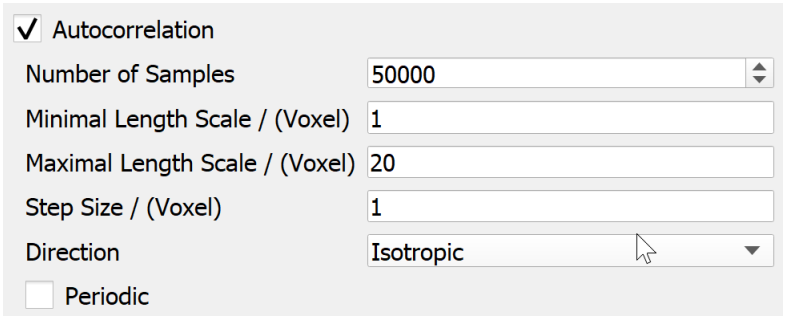


Minimum, Maximum and Mean Values, Standard Deviation and Variance can be computed for either Pore, Solid, All Materials, Chosen Materials or Chosen Material IDs.

Minimal, Maximal and Mean Values can also be determined slice-wise for a chosen direction and Pore, Solid, All Materials, Chosen Materials or Chosen Material IDs.

When checking **Autocorrelation**, further options appear below.

When **Autocorrelation** is selected, the similarity of voxels in a given distance between **Minimal Length Scale** and **Maximal Length Scale** is measured. This is similar to the MatDict command 2-Point Correlation and details are described in the MatDict handbook.



The **Correlation Length** is a measure on which length scale the values of the volume field change.

With **Spatial Intensity Histogram** a histogram of the values in the volume field is computed.

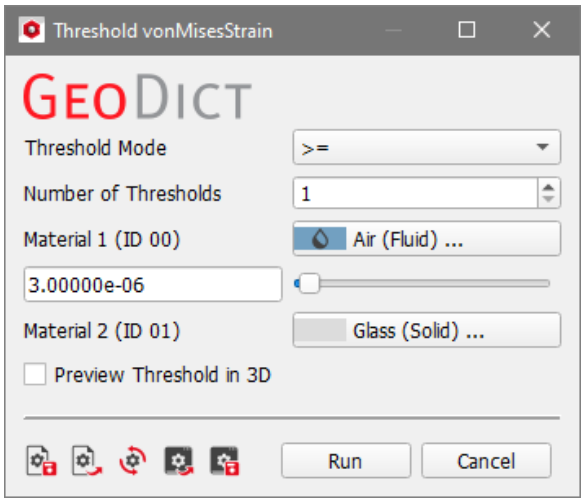
Clicking **Run** computes the chosen metrics. After the run is finished the result viewer opens and shows the results in the report tab. Additional plots may be available in the Plots subtab.

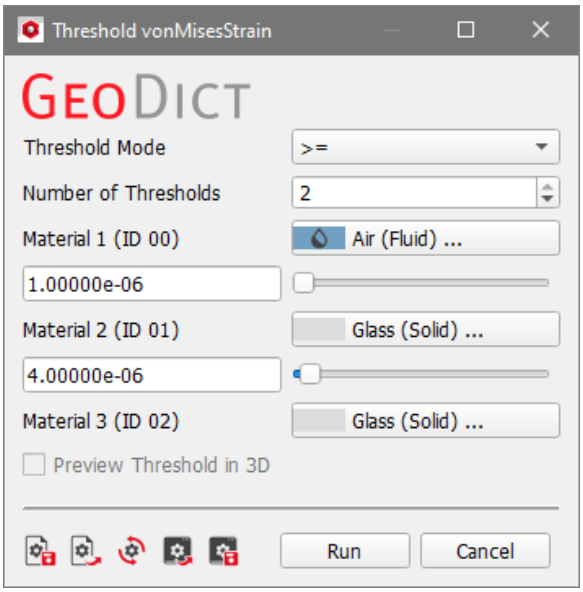
Threshold to Structure

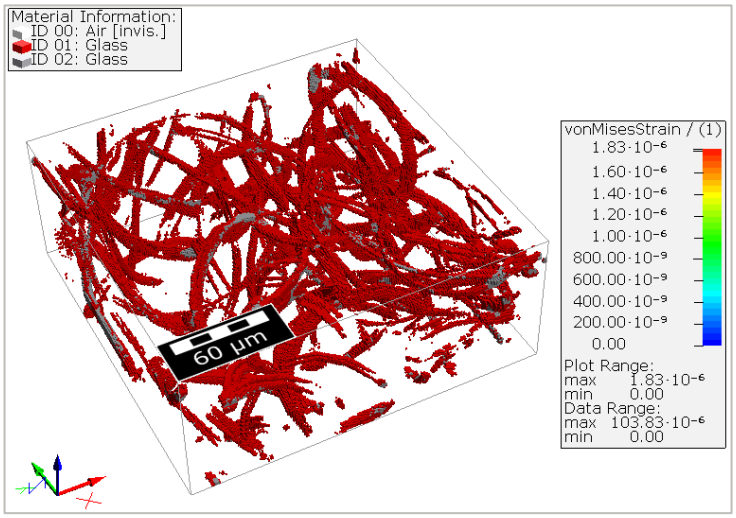
Select **Threshold to Structure** to create a structure with voxels above or below a defined threshold of a volume field. One or two thresholds can be defined.

If 3D rendering was chosen before, for one threshold, check **Preview Threshold in 3D** to visualize the created structure already before clicking **Run**.

Define e.g. 2 thresholds to create a structure with voxels of ID 01 where the von Mises Strain of the fibrous structure is above 1e-06, and with voxels of ID2 at locations with von Mises strain above 4e-06.



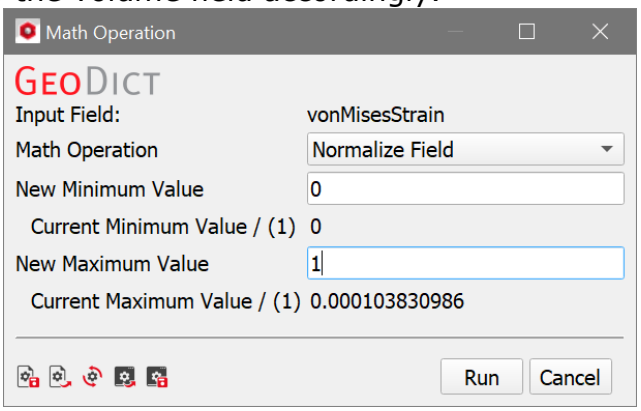




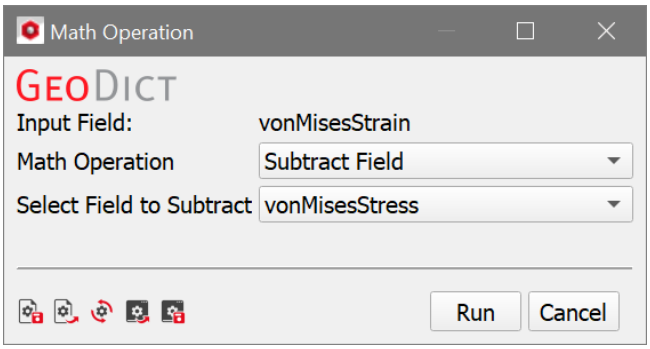
Math Operation

Choose **Math Operation** to open a dialog that allows to manipulate the volume field in different ways. Each math operation generates a new volume image containing the modified volume field. The volume fields can be saved in *.guf format or the modified volume file is saved, after the unwanted volume images were removed.

- **Normalize Field:** define a new minimum and maximum value and normalize the values of the volume field accordingly.



- **Subtract Field**: choose another volume field, e.g., from another result file, that will be subtracted from the current volume field.

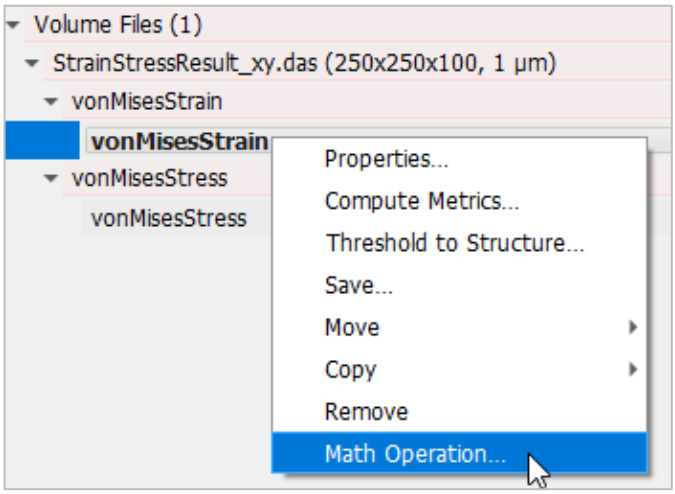


- **Add Field**: choose another volume field that will be added to the current one.
- **Compute Gradient**: compute the gradient for the current volume field.
- **Convert to Data Type**: choose a new data type (single, uInt32, uInt16 or uInt8) and convert all values of the current volume field to this type.

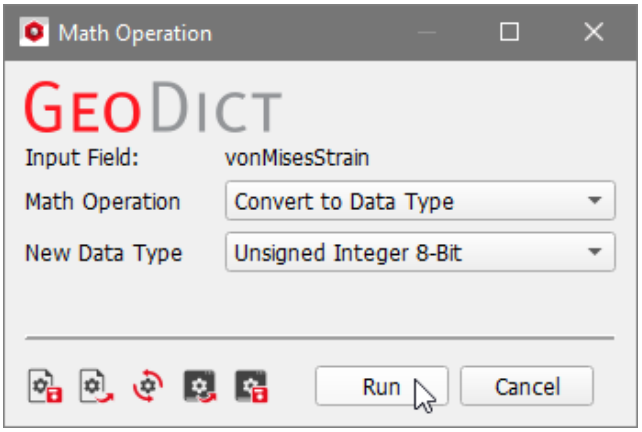
- **Add (Subtract) Constant Value**: add or subtract a constant value from the volume field.
- **Multiply Constant Value:** multiply each entry in the volume field by a constant factor.

With the tools from the status section volume fields can be saved as RAW-files. For example, the field "vonMisesStrain" can be saved in the following way.

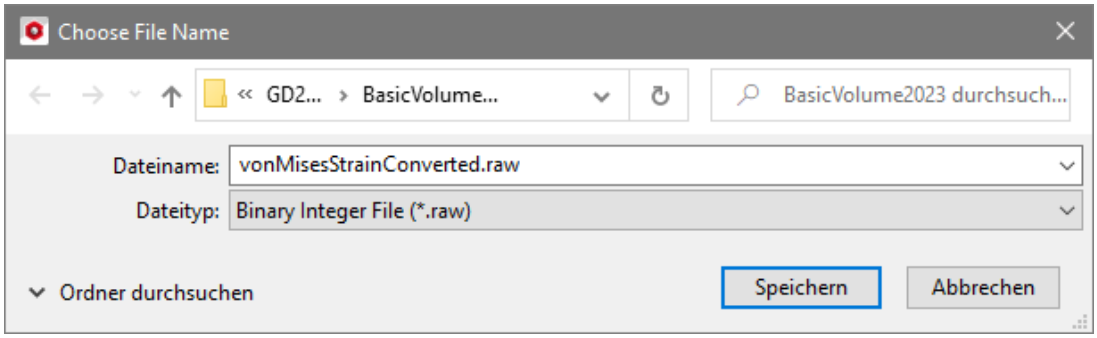
1. First, convert the data in the field to the right data type. Right-click on the **vonMisesStrain** field and choose **Math Operation...**.

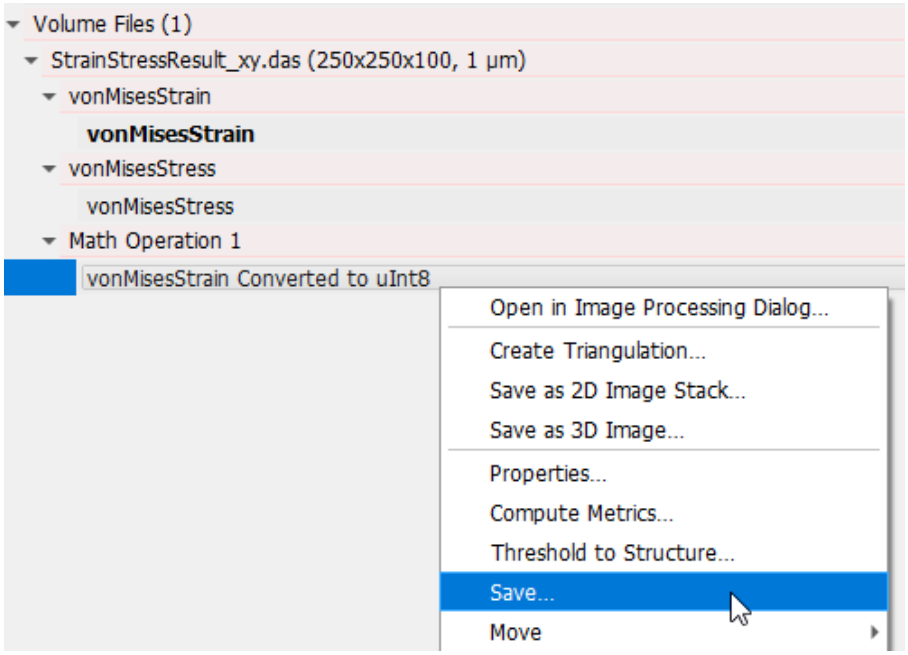


2. In the dialog select **Convert to Data Type** from the first pull-down menu and **Unsigned Integer 8-Bit** from the second. Then click **Run**.



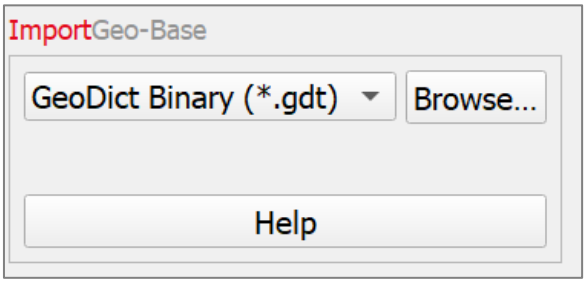
3. A new Volume Image appears under the currently loaded Volume File: **Math Operation 1**. There, the new Volume Field **vonMisesStrain Converted to uInt8** is shown. Right-click on it and choose **Save.**
4. Select a name and choose **Binary Integer File (*.raw)** as file type. Then the volume field is saved in the current project folder.



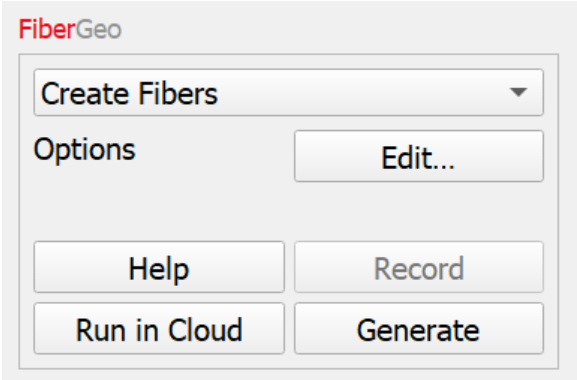


MODULE SECTION

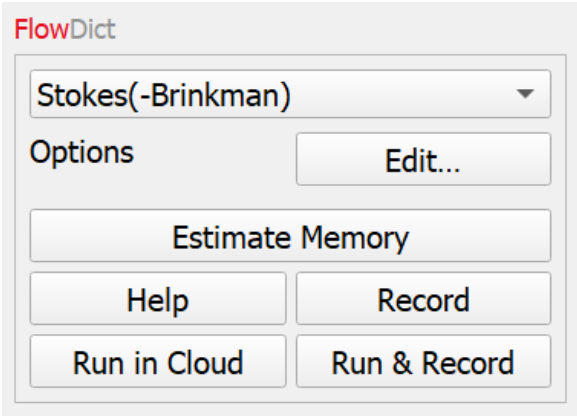
The heading of the **Module** section changes to the GeoDict module selected from the menu bar. The GeoDict modules are organized into modules to **Import** and pre-process files and 3D image data, generator and structure-modifying modules to **Model** microstructures, structure analyzing modules to **Analyze**, properties predictor modules to **Predict**, and modules to **Export** files to other formats.



The module section contains a pull-down menu, from which the user can choose a command that is executed. Depending on the chosen command, there might be a **Browse...** button for choosing files or an **Edit...** button, where the options necessary for GeoDict's generators, modifiers, or solvers, can be edited. The **Help** button directly links to the User Guide Reference for the chosen command in the corresponding module handbook.



The module section often includes a **Record** button, which is selectable when **Macro → Start Macro Recording...** is selected in the menu bar. Clicking **Record** allows recording the settings and actions of the module without obtaining the results (yet), while **Run & Record** starts the computation and additionally records the action in the macro file.



Depending on the module, the button **Generate**, **Run**, or **Export** starts the actions of the generator, the solver or the export. For ProcessGeo and LayerGeo, the button specifies the particular modifying process (Reassign, Rescale, Compress, Attach, Erode, Dilate, etc.).

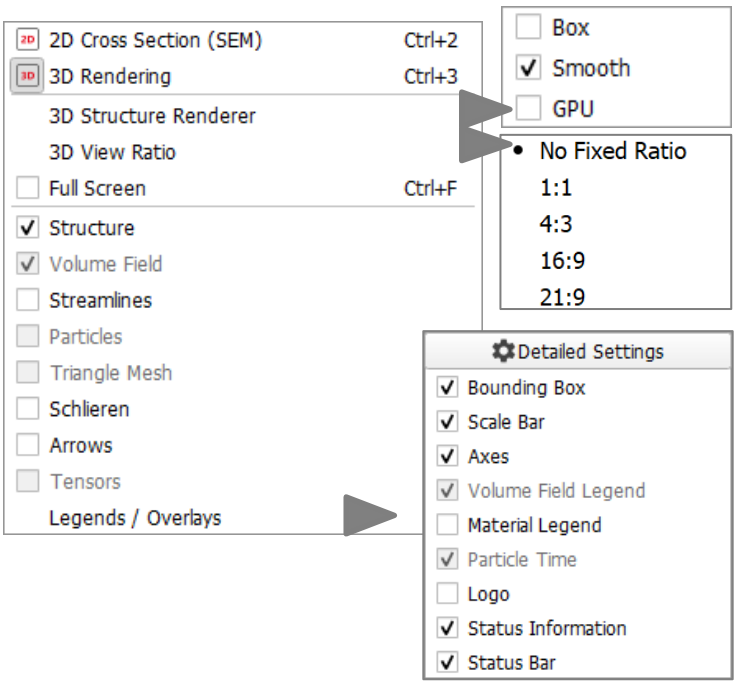
For some modules, the module section includes an **Estimate Memory** or **Estimate Memory & Disk-Space** button, that becomes active for the functionalities that support such an estimation. It allows to estimate the memory (and disk-space) required for the computation before starting the computation.

The button **Run in Cloud** allows to perform the calculations in the GeoDict Cloud. More information on how to start a calculation in the cloud can be found in the High Performance handbook.

The use of the modules is explained in each of the module's handbooks.

VISUALIZATION AREA AND VISUALIZATION PANEL

Initially, the **Visualization panel** shows information about the image displayed in the **Visualization area**. The image might be of a fibrous-, paper-, granular-, sintered-, pleated-, woven-, or grid-structure created with one of GeoDict's structure generators, an image from an opened *.gdt file, an image imported and segmented with ImportGeo-Vol or ImportGeo-CAD from a stack of 3D image data (µCT, FIB/SEM), or other structure models.



Different parameters or settings can be selected in the **View** menu and in the **Settings → Settings...** menu, see page 22. The visualization of computational results changes the panel, by activating other tabs, to access options to visualize the results optimally.

Select to view the structure in **2D Cross Section (SEM)** or **3D Rendering** mode.

In **3D Rendering**, render the structure on the graphics card (**GPU**) or the main processor (**Box** with raycasting or **Smooth** with raycasting). Volume raycasting is an image-based volume rendering technique that computes 2D images from 3D volumetric data sets.

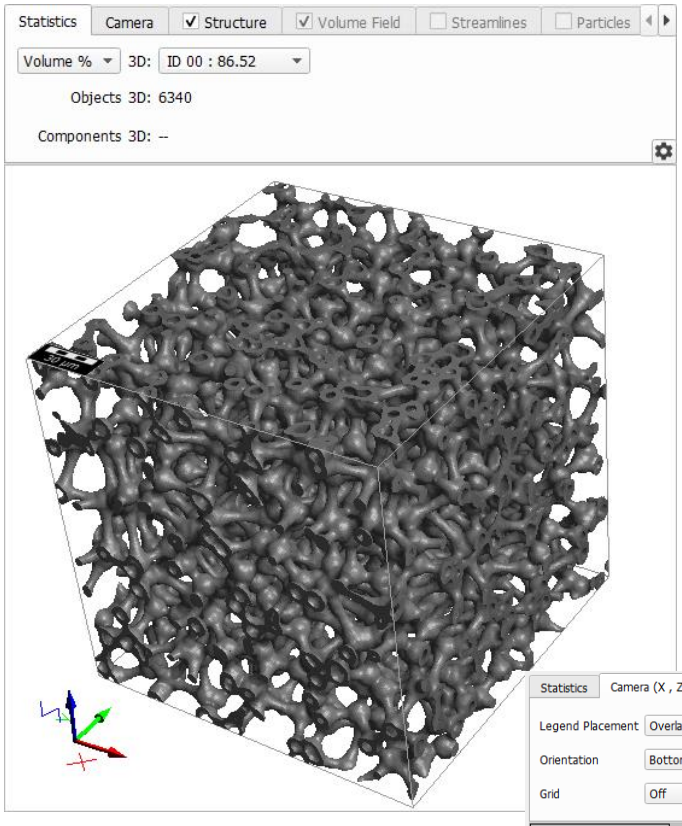
In 2D Cross Section view and 3D Rendering, zoom in and out smoothly by keeping the right mouse button clicked and moving the mouse forward and backward. Or zoom stepwise by clicking the **Zoom** buttons on the **Camera** tab. In 3D Rendering, zooming in and out can also be done by scrolling the mouse wheel.

Select **Full Screen** to make the Visualization area occupy the entire computer screen. Pressing the **Esc** key on the keyboard returns the program to the normal display.

When un-checking **Structure**, the complete structure disappears from the display. In the same way loaded results, like **Volume Fields**, **Streamlines, Particles, Triangle Mesh, Schlieren, Arrows and Tensors** can be switched on and off in the visualization.

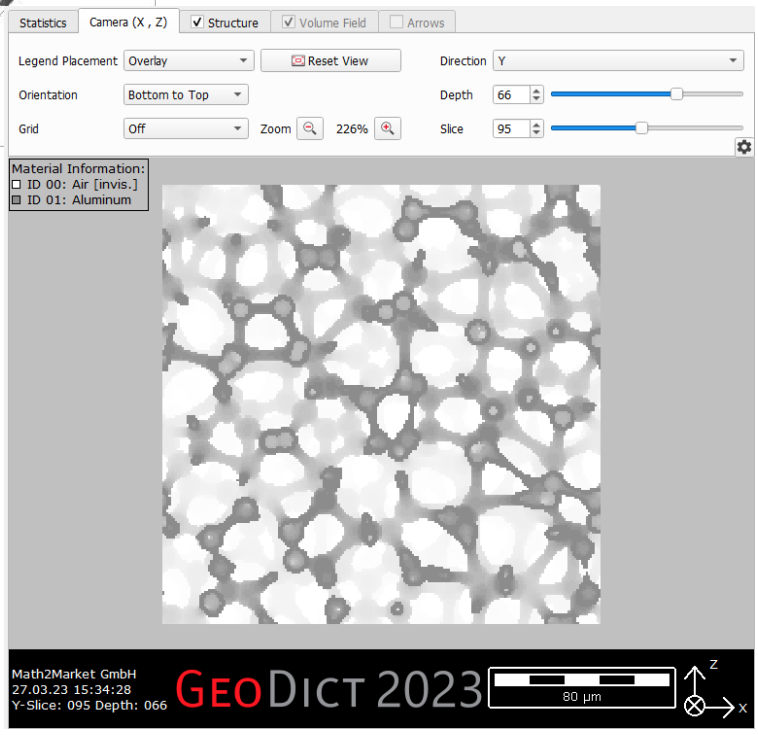
To start the visualization of results, a result file must be loaded through **File → Load Volume Field ...** or **Load Particles ...** in the menu bar, or directly by loading from the **Visualization** tab of the GeoDict **Result Viewer**.

Among the **Legends / Overlays**, unchecking **Bounding Box** makes the border surrounding the domain disappear in **3D Rendering**. Unchecking **Scale Bar** makes the scale bar disappear, unchecking **Axes** hides the coordinate stencil from the display while in **2D Cross Section (SEM)** or in **3D Rendering**. Unchecking **Volume Field Legend** and/or **Material Legend** hides the legends of a volume field or for the constituent materials present in the structure.



The **Particle Time**, displayed for a particle simulation, the display of the GeoDict **Logo**, and for the 2D cross Section view the **Status Information** or the display of the **Status Bar** can be switched on and off as well.

More detailed information about visualization in GeoDict can be found in the Visualization handbook of the User Guide.

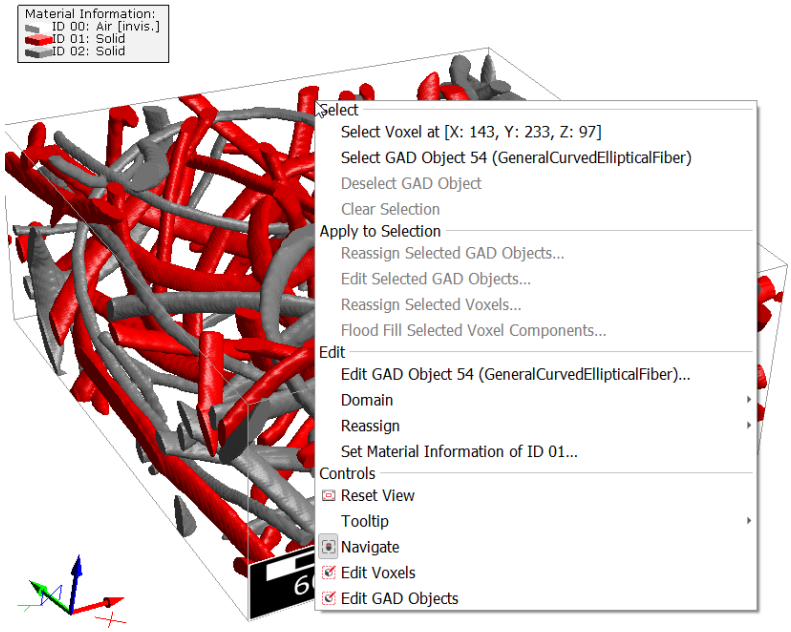


SHORTCUT TO SELECTION AND EDITING FOR GDT AND GAD

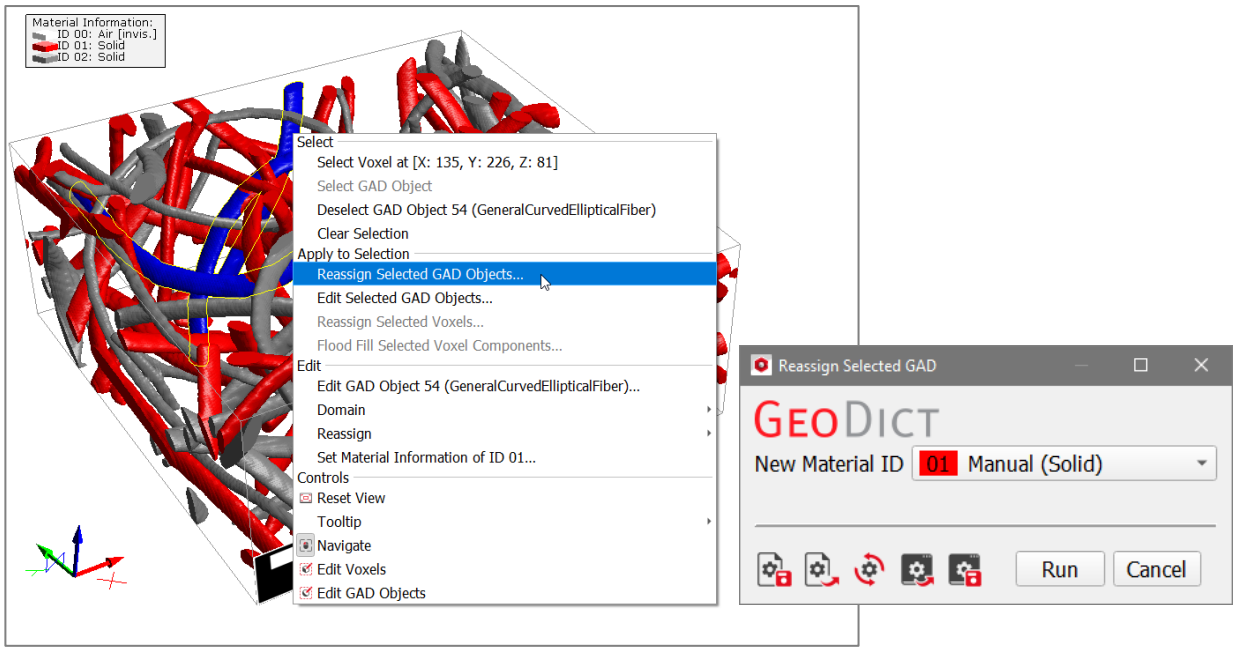
Part of the selection and editing functionalities explained on pages 57 ff. can be accessed directly by a right mouse click in the structure shown in the Visualization area.

In this way, voxels and / or GAD objects can be selected and are added to the **Voxel Selection** dialog or the **GAD Object Selection** dialog.

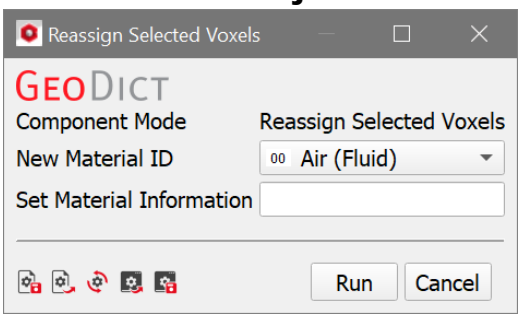
Previously selected GAD objects can be removed from the dialog (**Deselect GAD Object**), or the selections of both dialogs can be removed completely (**Clear Selection**).



After a selection was made, different modifications can be applied to the selection (**Apply to Selection**). Choose **Reassign Selected GAD Objects** to assign a new material ID to the selected objects.

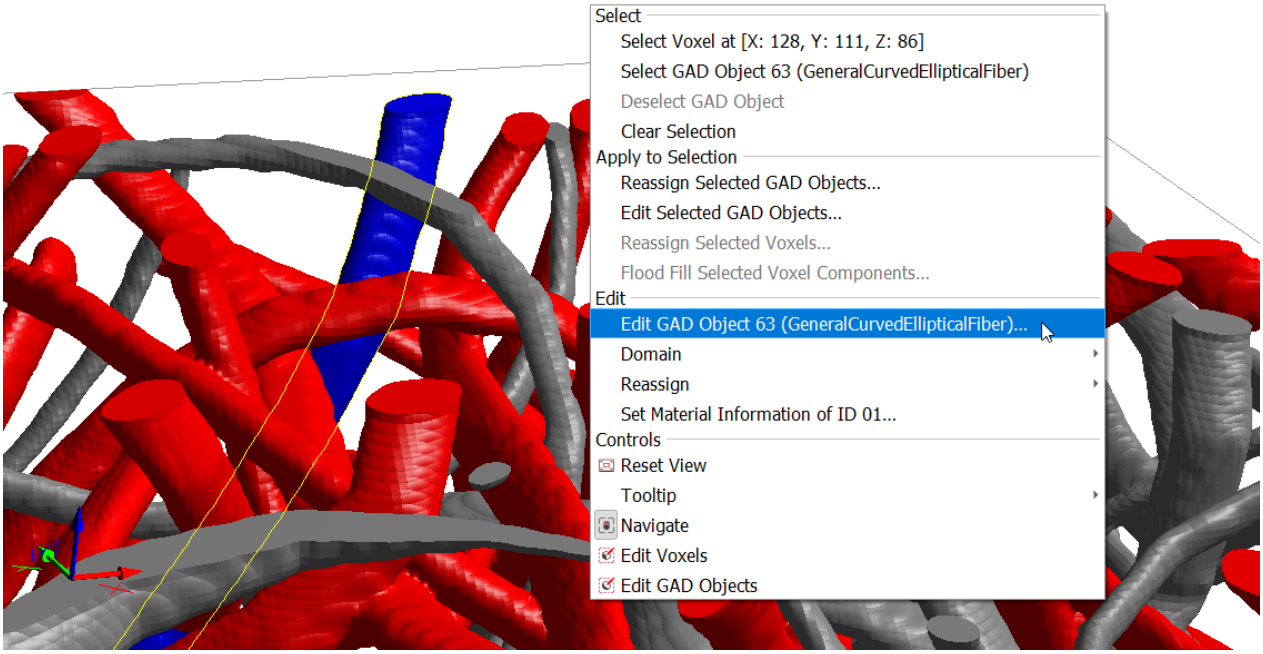


With **Edit Selected GAD Objects**, all objects listed in the **GAD Object Selection** dialog can be modified at once.

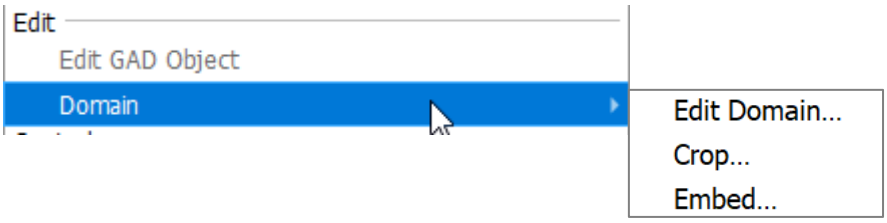


Voxels listed in the **Voxel Selection** dialog or the whole components connected to them, can be reassigned to a new Material ID with **Reassign Selected Voxels** or **Flood Fill Selected Voxel Components**. Choose the new Material ID for the operation.

By a click with the right mouse button on the structure, it is also possible to **Edit** the structure at the point where the right click was performed on without making any selection of voxels or GAD objects. **Edit GAD Object** allows to modify the GAD object on which the right click was made.

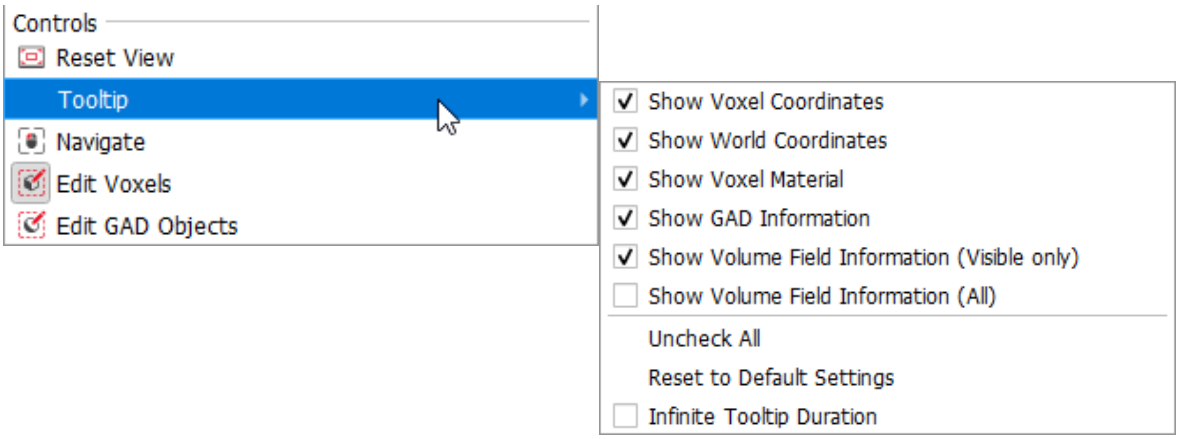


Under **Domain** the current domain can be edited and access to the ProcessGeo functionalities **Crop** and **Embed** is given.



With **Reassign** Material IDs and Materials can be reassigned as it is described in the ProcessGeo handbook. When choosing **Reassign Material ID**, **Reassign Material** or **Reassign Material of Material ID**, the Material ID or Material at the voxel where the right click was made is set as old Material ID or Material. With **Reassign Voxel at** the voxel at this point can be reassigned to another Material ID. **Flood-Fill Component at** is similar to Flood-Fill Component for a selection of voxels (see page 59), but here for the current voxel. Finally, with **Reassign GAD Object** the GAD Object at this position can be reassigned to a new Material ID.

Select the options available under **Controls**, to **Reset View** settings (also available in the Camera tab on the Visualization panel) according to the startup-settings, to switch between the icons of the toolbar for the mouse functionalities (**Navigate**, **Edit**

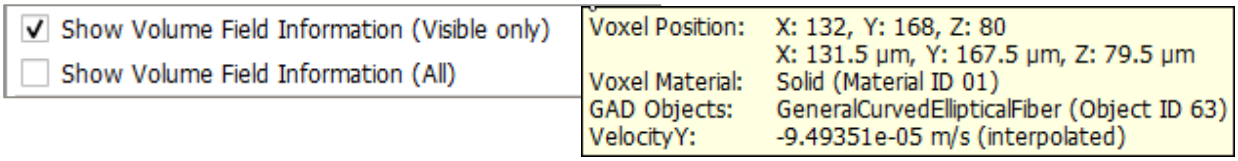


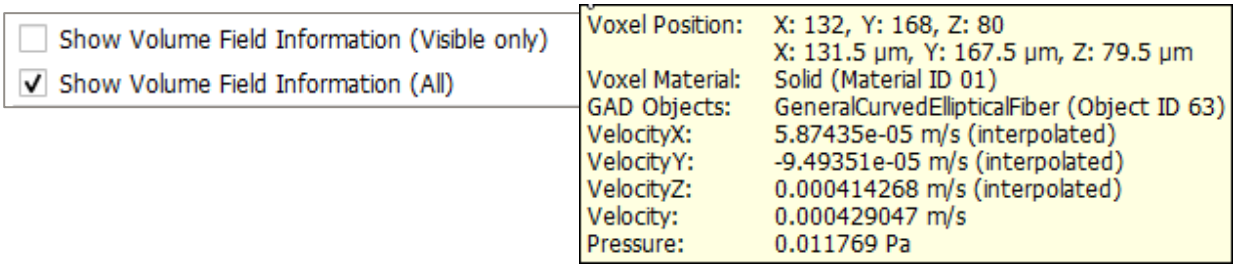
Voxels and **Edit GAD Objects**), and to change the settings for the **Tooltip** shown for the structure.

Choose, which information should be shown for the position of the mouse pointer in the structure. For the position of a voxel, the coordinates can be shown in number of voxels in each direction (**Show Voxel Coordinates**) or as coordinates in length units with respect to the origin of the structure (**Show World Coordinates**).

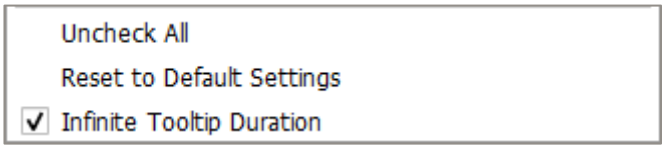
Check **Show Voxel Material** to add the Material and Material ID information to the tooltip. Check **Show GAD Information**, to show the object type and Object ID of the GAD object the voxel belongs to (only shown if analytic object data is available for the structure).

Select **Show Volume Field Information (Visible Only)** or **Show Volume Field information (all)** to show the value of the currently selected volume field, or of all volume fields available, at the current position, if a volume field is loaded for the structure.





Use **Uncheck All** to deselect all boxes of the Tooltip options, or **Reset to Default Settings** to reload the GeoDict default settings for the tooltips.

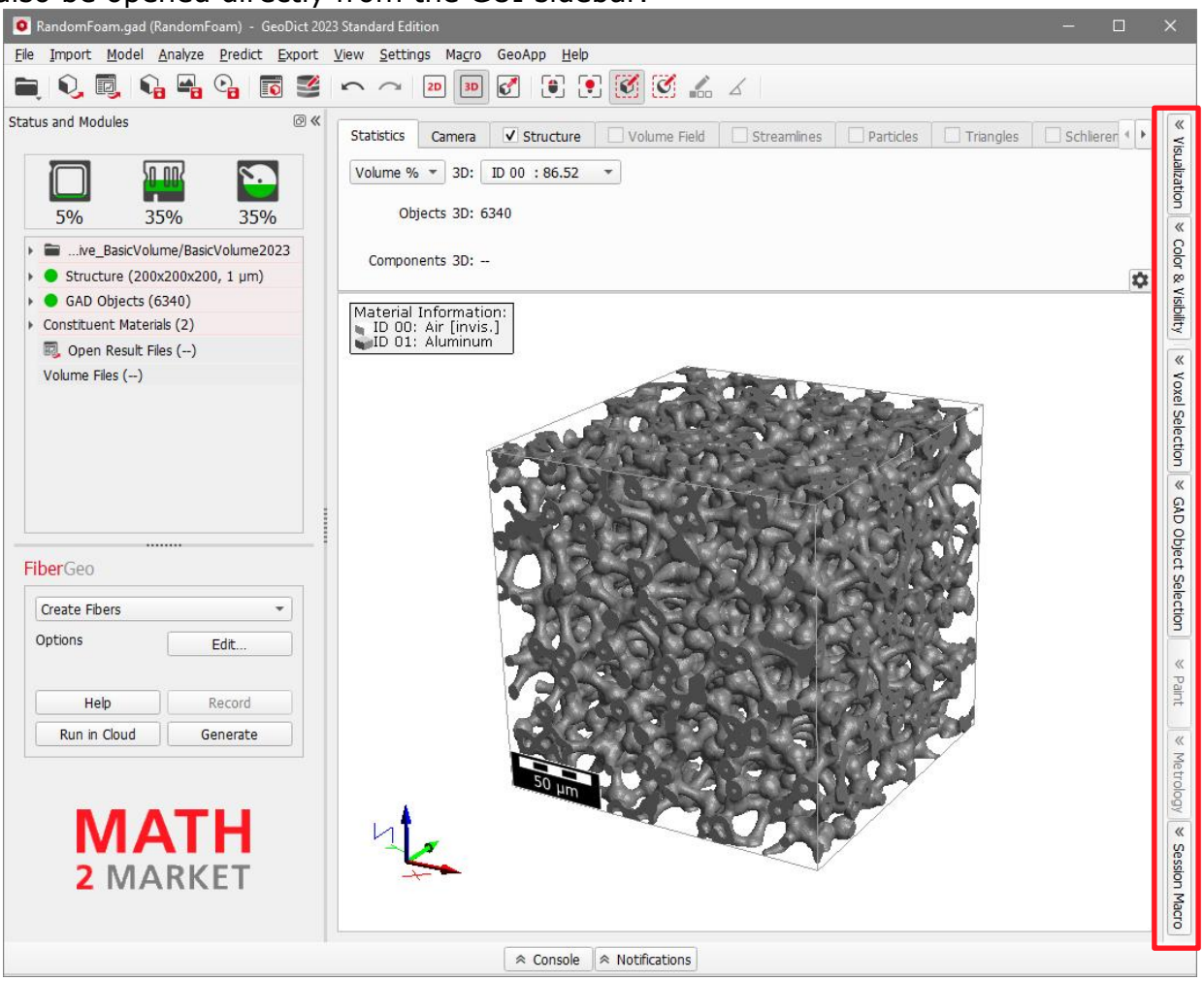


Check **Infinite Tooltip Duration** to prevent the tooltip from vanishing after a few seconds.

GUI Sidebar

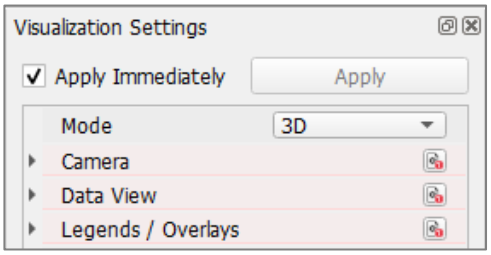
Starting with GeoDict 2020, many of the options that were previously available only under the **View** menu in the menu bar, have moved for convenience of usage to the sidebar to the right of the GUI.

Dialogs for **Visualization**, **Color & Visibility Settings**, the editing and modifying functions (**Voxel Selection**, **GAD Object Selection** and **Paint** mode), the measuring of distances and angles (**Metrology**) and the **Session Macro** can now also be opened directly from the GUI sidebar.



This sidebar now controls all visualization settings, editing, modifying, and measuring functionality centrally. It can be expanded and collapsed by clicking on the icon at the bottom. Each dialog can also be expanded and collapsed by clicking on the icon at the top of the tab.

When expanded, the sidebar panel can be undocked by clicking the icon at the top of the open panel and, so, turned into a dialog that can be moved around.



Information about the **Visualization** tab and the **Color & Visibility** tab from the GUI sidebar can be found in detail in the Visualization handbook of the User Guide.

The **Session Macro** tab is explained in the Automation handbook.

The functionality of the tabs **Voxel Selection**, **GAD Object Selection**, **Paint** and **Metrology** is explained below.

WHAT ARE VOXELIZED AND ANALYTIC STRUCTURE MODELS?

Structure models in GeoDict can be described in two different ways:

- **Analytic representation**: The structure is described analytically (e.g. multiple spheres with given diameters and positions). The structure information is stored as GAD-objects (GAD = **G**eoDict **A**nalytic **D**ata).
- **Voxel representation**: The structure is described by its voxel grid.

Editing and modification of structure models can be done on the structure's voxel geometry description or analytic description.

Simple and complicated microstructures can be edited by manual drawing, e.g., to correct problematic boundary effects. Among other applications, voxel and analytic data editing can be used to remove artifacts from 3D structures built from imported 3D-image data (micro-CT, nano-CT, SEM, …).

For structure models created using GeoDict's generator modules, undesired fragments of the structure can be easily modified or eliminated, without having to reset the parameters and generate again.

This direct editing or modification of voxelized structure models is a complement to the GadGeo module. GadGeo generates and edits on the analytic level on structures with available analytic information, whereas editing is also applicable to structure models with voxelized formats.

Structure models can be manually edited with GeoDict, using the following icons in the toolbar:

2D / 3D		**Edit the previously selected voxels.**
2D / 3D		**Edit** the previously selected **analytic objects**.
2D		Edit in a way similar to the Windows standard editor **Paint**. Observe results in 3D (edited objects can be three-dimensional)

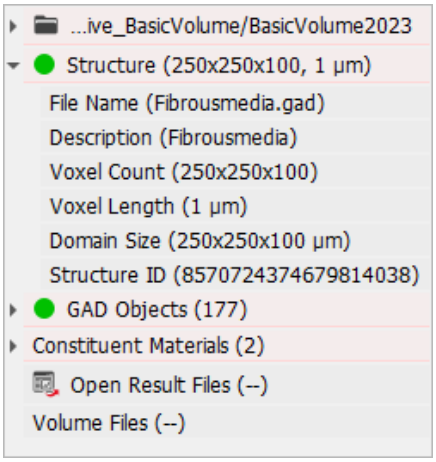
Part of the functionality for structure editing can be accessed also by a right mouse click in the visualization area, see page 53.

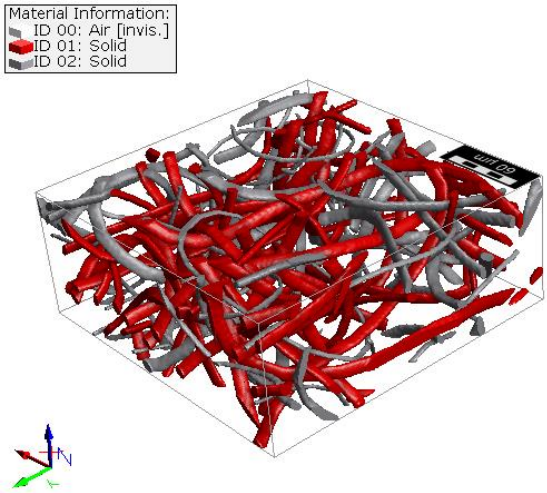
Here, as a simple structure example, a fibrous media model is generated with FiberGeo. The structure consists of 177 GAD objects, but also the voxel representation is available. The structure model contains curved fibers of two different raw materials, initially set as Manual (Solid).

Below follow examples to edit and modify this fibrous media model structure in both representations. After editing, the structure must be saved to preserve all modifications.

VOXEL SELECTION AND EDITING

The voxel structure is loaded (indicated by the green dot before Structure) and also analytical data fitting to the voxel data is available (indicated by the green dot before GAD Objects).

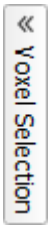


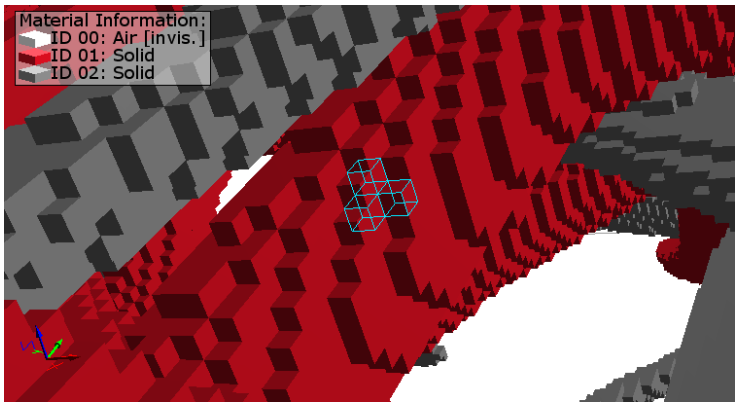


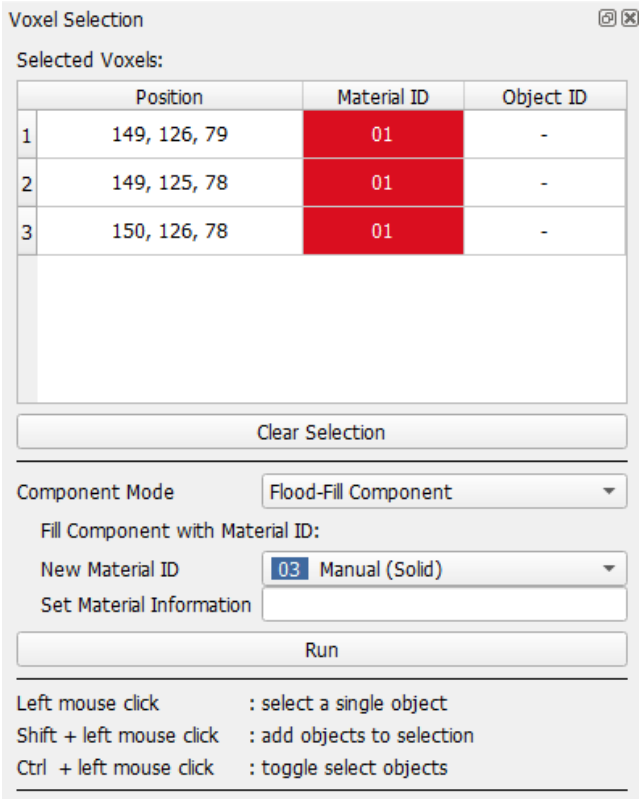
We now want to edit the structure by editing the voxels. The analytic object information is not modified, and therefore the analytic object description in the model does not fit anymore to the loaded structure. The initially green dot before **GAD Objects** turns yellow, if one of the operations listed below is applied.

The voxels forming a fiber in the structure model are edited in 2D Cross Section (SEM) view or in 3D Rendering, as follows:

1. Select voxels:
   a. Zoom into the structure by pressing and holding the right mouse button while moving the mouse back and forth or scroll the mouse wheel.
   b. To enter the **Voxel Selection** mode, click the corresponding tab in the GUI sidebar or the  icon in the toolbar. The **Voxel Selection** dialog opens.
   c. Click on the voxel(s) that should be edited. For several voxels, press and hold the Shift key on the keyboard while clicking the voxels. A cyan-colored frame appears at the edges of the selected voxel(s). At the same time, the parameters defining the voxel(s) (Position as X, Y, Z coordinates and Material ID) appear in a table in the **Voxel Selection** dialog.





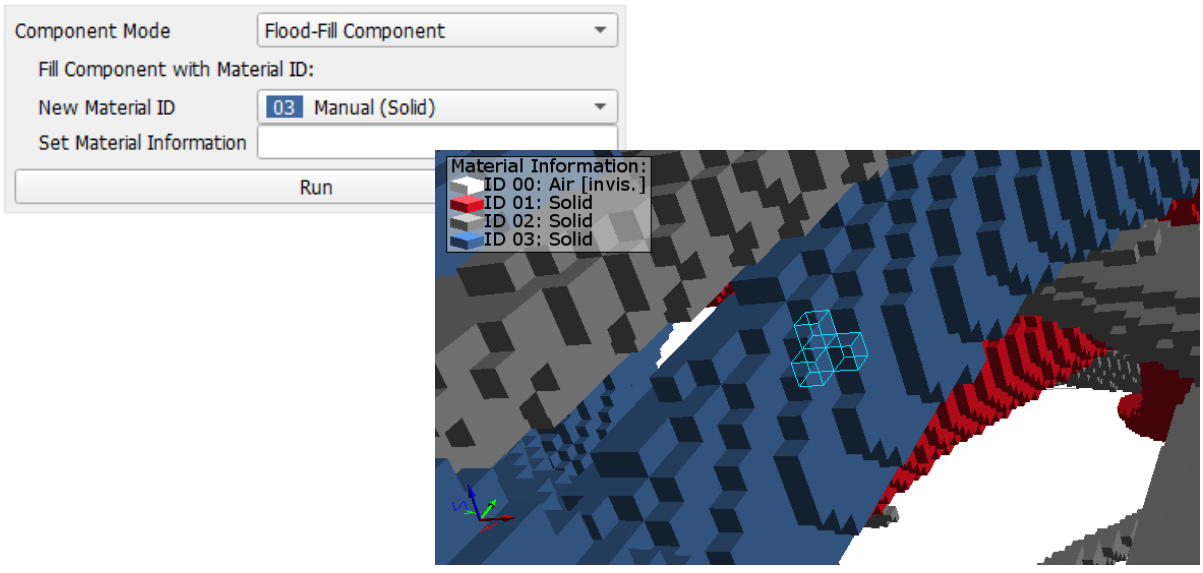


d. If a voxel is mistakenly selected, hold Ctrl and click again on that voxel.

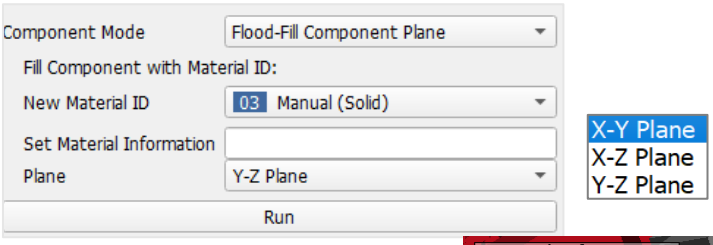
e. Clicking **Clear Selection** in the **Voxel Selection** dialog removes all voxels from the selection.

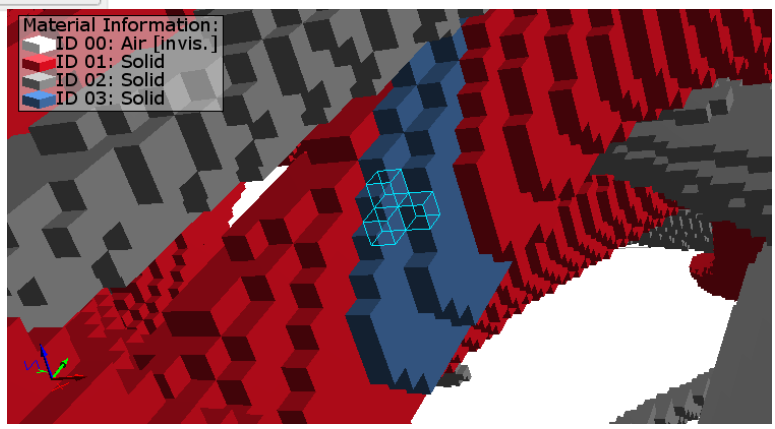
2. Edit voxels by selecting one of the **Component Mode** commands and clicking **Run**:

a. **Flood-Fill Component**: Fill the selected voxels and the components connected to them (see page 26) with a **New Material ID** chosen from the pull-down menu.

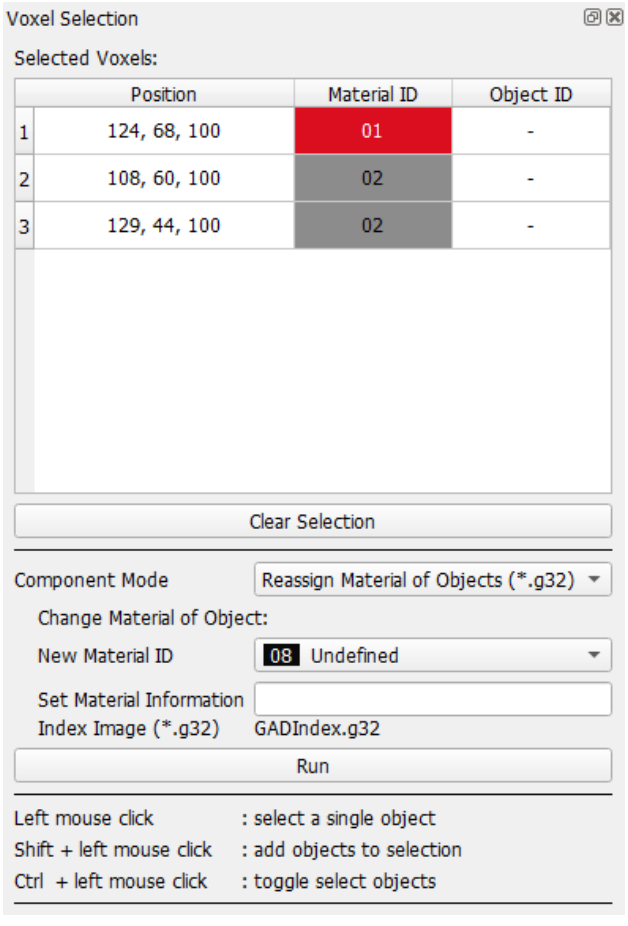


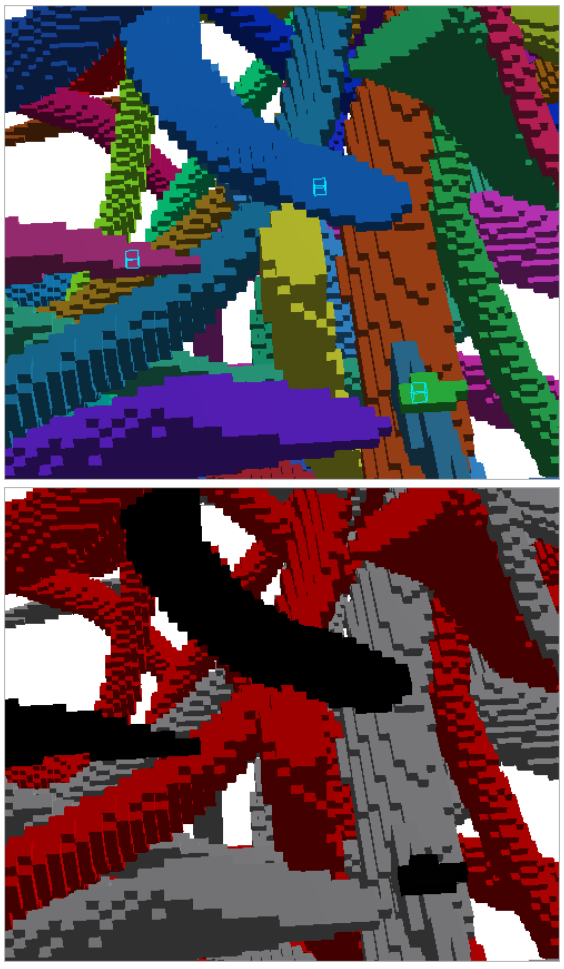
b. **Flood-Fill Component Plane**: Fill the selected voxels and the components connected to them with a **New Material ID** only in the **Plane** chosen from the pull-down menu.





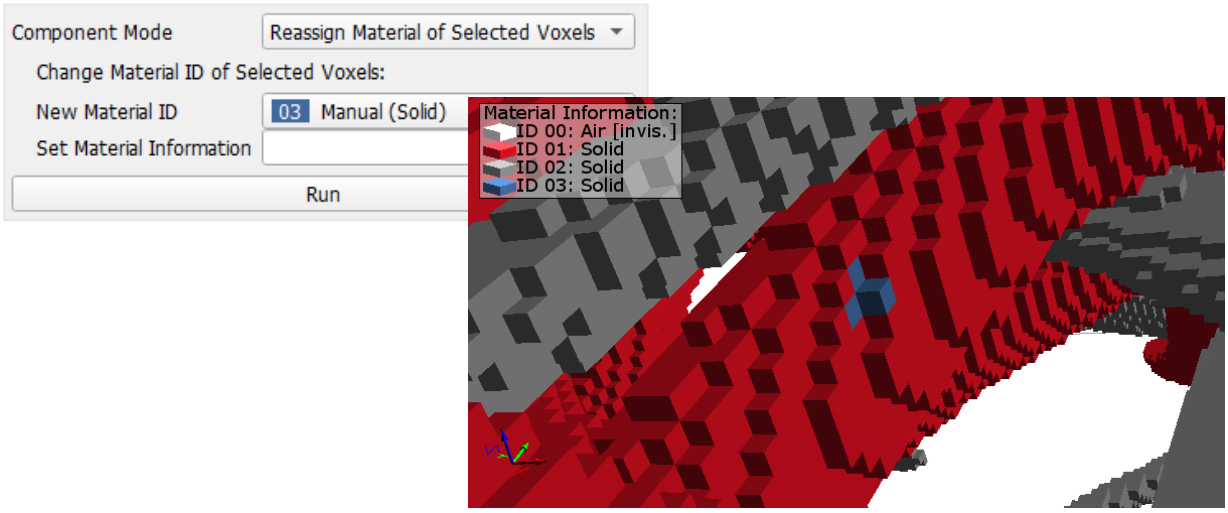
c. **Reassign Material of Objects (*.g32):** If a *.g32 file with object indices is loaded in the GeoDict GUI (e.g., created by right clicking on Objects in the Project Status Section and selecting Create GAD Index Image, see page 42), the Object ID is additionally shown for each voxel selected.



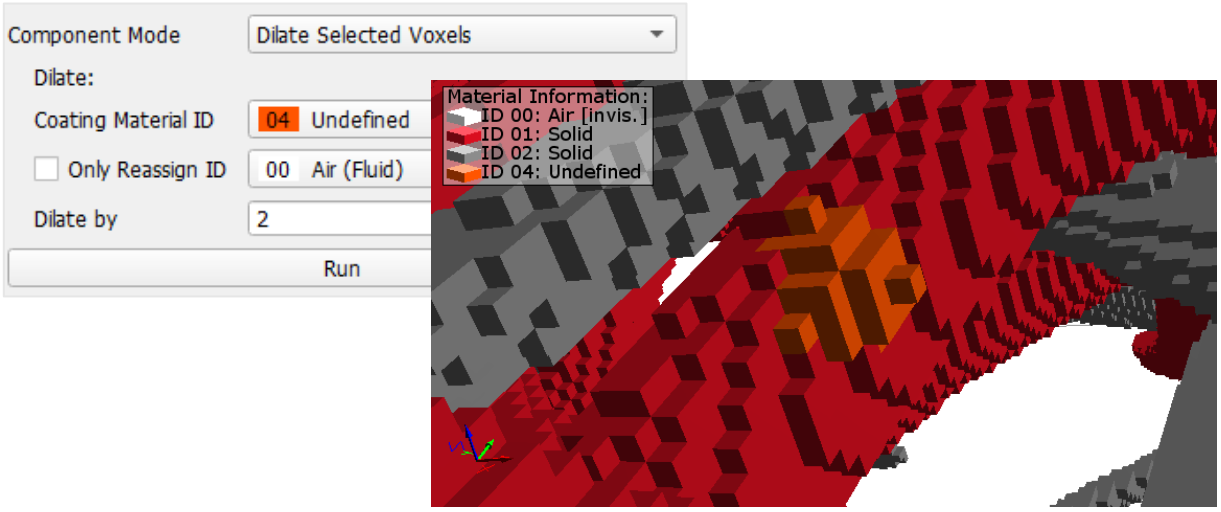


Select a **New Material ID** and click **Run**, to assign the new material to all voxels that belong to the same Object ID as the voxels selected (here Object IDs 76, 104 and 163).

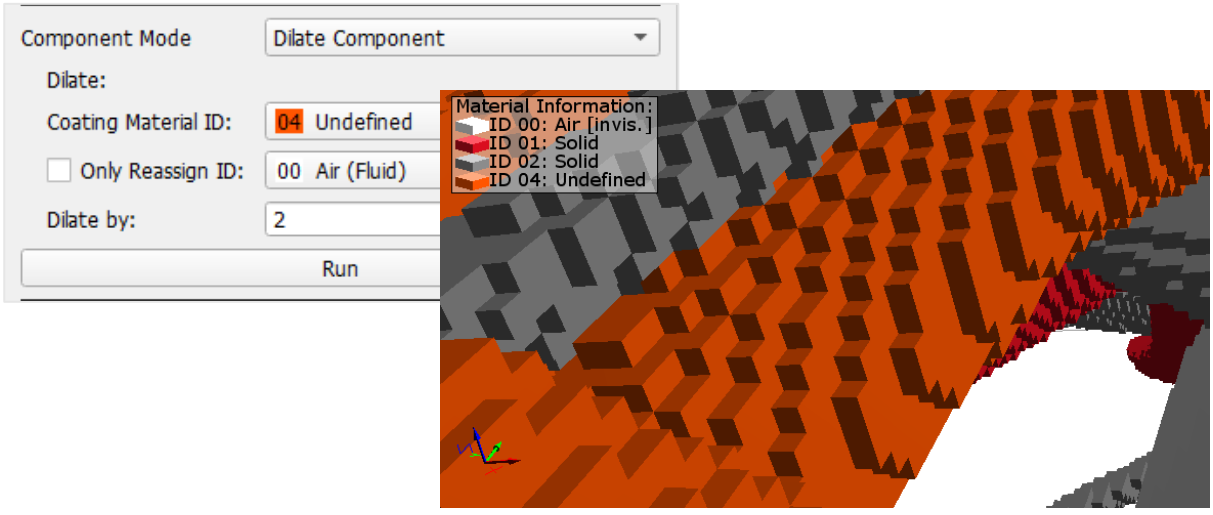
d. **Reassign Material of Selected Voxels**: The material ID of the selected voxels can be changed by selecting a **New Material ID** from the pull-down menu.



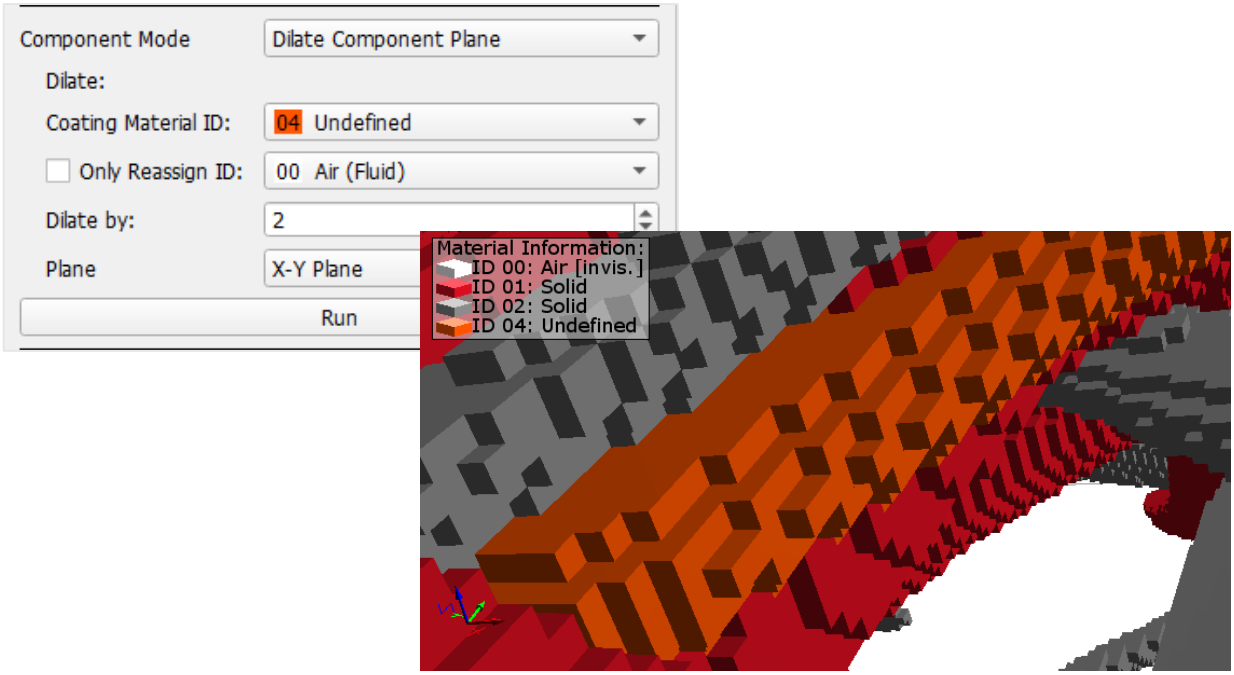
e. **Dilate Selected Voxels**: It is possible to dilate the voxels by coating them with another material chosen from the **Coating Material ID** pull-down menu by a certain number of voxels (**Dilate by**). An explanation for the dilate command can be found in the ProcessGeo handbook of this User Guide.



f. **Dilate Component**: Also possible is to dilate the selected voxels and the components connected to them with the **Coating Material ID** by a certain number of voxels (**Dilate by**).

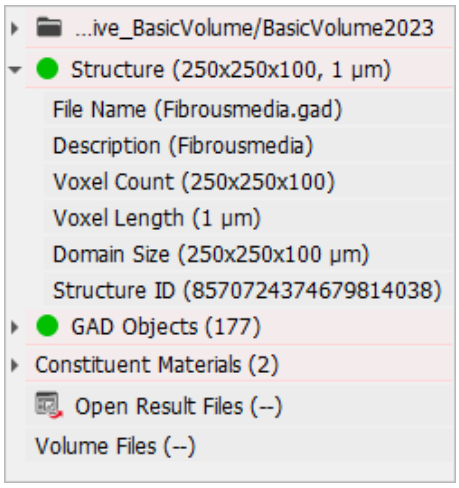


g. **Dilate Component Plane**: Dilate the selected voxels and the components connected to them only in the **Plane** chosen from the pull-down menu with the **Coating Material ID** by a certain number of voxels (**Dilate by**).



All these operations can be undone by clicking the icon or CTRL+Z.

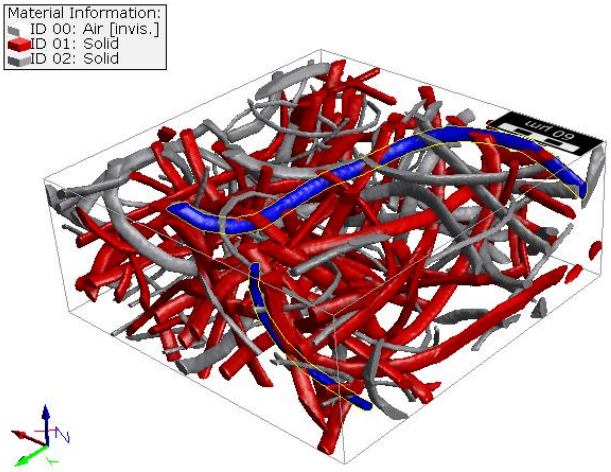
GAD Object Selection and Editing



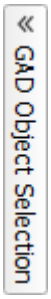
The same fibrous media model as in the section above is edited, but now the analytic objects are modified. This is possible if a structure in GAD format is loaded, or a structure in GDT file format with analytic object information contained in the GDT file. The information that appears in both cases in the **Project Status**, is equivalent.

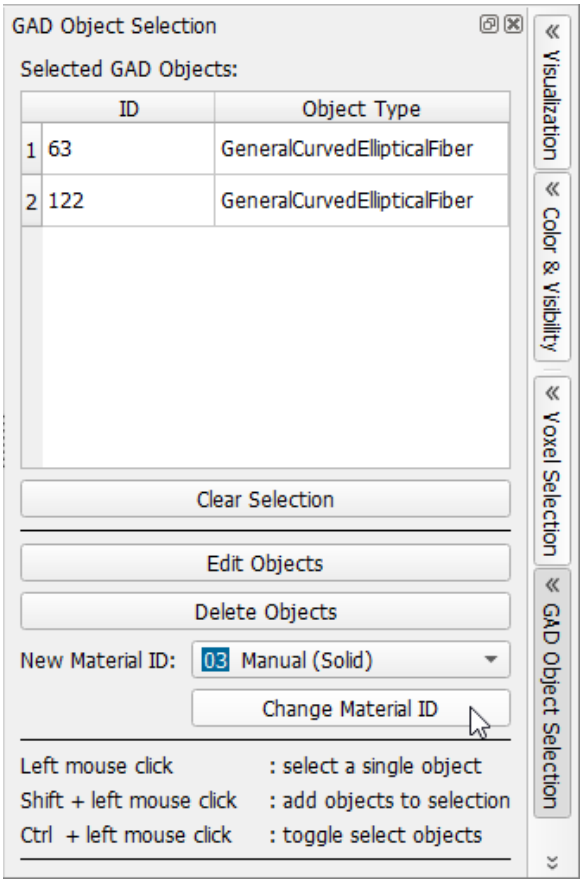
In contrast to editing the voxel structure, editing the analytic objects preserves the analytic object information in the file.

The analytic objects (fibers) in this fibrous structure model can be edited, while visualizing the material model in 2D Cross Section (SEM) view or in 3D Rendering, as follows:



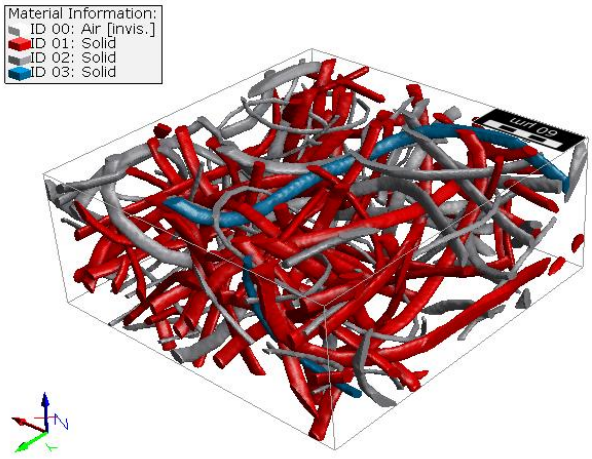
1. Select analytic objects:
   a. To enter the **GAD Object Selection** mode, click the corresponding tab in the GUI sidebar or the  icon in the toolbar. The **GAD Object Selection** dialog opens.
   b. The upper table shows the **ID** number and the **Object Type** of the selected fibers.
   c. Click on the fiber that should be edited to select it. For several fibers, press and hold the Shift key on the keyboard while clicking the fibers. The selected fiber(s) appear(s) highlighted.
   d. If a fiber is mistakenly selected, press and hold the CTRL key and click on the fiber again.
2. Edit analytic objects:
   a. When clicking **Delete Objects**, all selected fibers, which are listed in the upper table, are deleted and taken out from the structure model.
   b. **Change Material ID:** The material ID of the selected objects can be changed by selecting a new material ID from the pull-down menu and clicking **Change Material ID**.





The selected fiber(s) still appear(s) highlighted (and perhaps makes it difficult to see the change in the material) until the user clicks **Clear Selection**.

Now the fibrous structure model contains fibers of three different materials.



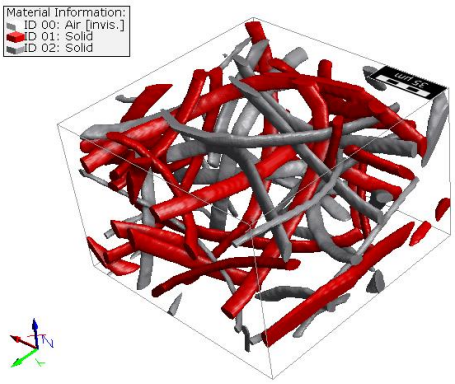
It is also possible to **Edit Objects** in a dialog which looks similar to the GadGeo **Edit GAD Objects** dialog, but it contains only the chosen GAD Objects. With a right click on a single selected object the Edit menu for only this object can be opened. The GadGeo handbook describes how the GAD Objects can be edited.

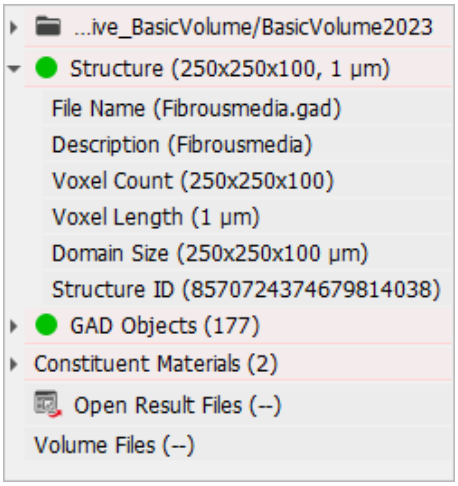
PAINT

The **Paint Mode** editing works in a way similar to the Windows standard editor **Paint**. Editing is always done in 2D (View → 2D Cross-Section (SEM)) and the effects can be seen later in 3D (View → 3D Rendering).

The **Paint Mode** operates directly on the voxel representation of a structure. Thus, using the paint mode on a structure with analytic object information does not change the analytic data. This can be observed in the green dot before GAD Objects turning yellow in the **Project Status** section after applying the paint mode. After editing in the paint mode, the changed structure must be saved to store the modifications.

As an example, a fibrous media model is edited with **Paint Mode**.





The **Paint** mode is used as follows:

1. Select **View** → **2D Cross-Section (SEM)** in the menu bar or click the 2D icon in the toolbar.

   In the Visualization panel, above the Visualization area, click the Camera (Y, Z) tab and use the **Direction** pull-down menu and the **Slice** slider to navigate to the location where the editing should take place. Here, direction Z and slice 90 is selected.

2. Click the **Paint** tab on the GUI sidebar or the  icon in the toolbar to open the **Paint Settings** dialog. The **Paint** tab is greyed out and not accessible when the structure is viewed in 3D rendering.

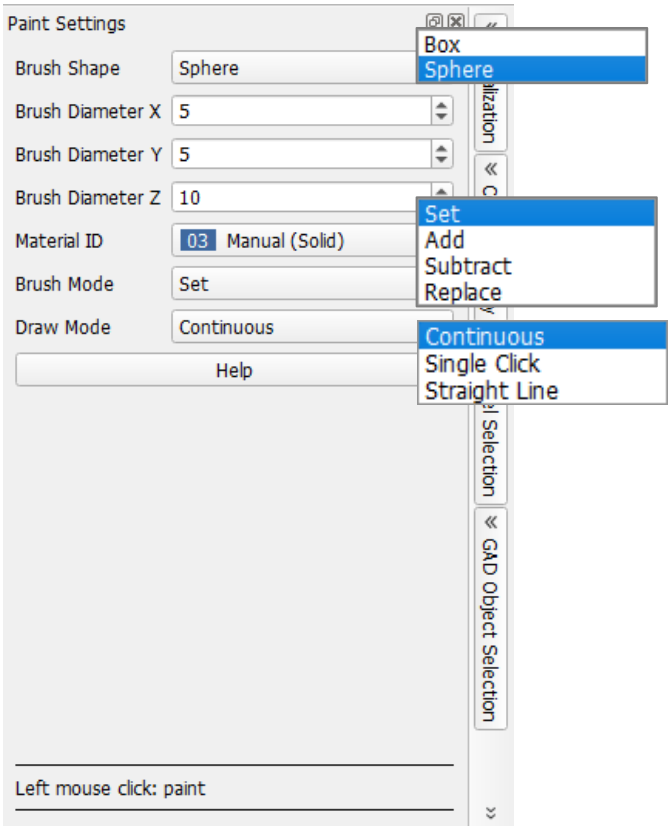
3. In the opening **Paint Settings** dialog, editing is done using a brush (Make sure, that the  icon is selected, so that the brush is active!) and its shape and size are set in the **Brush Shape** pull-down menu and in the **Brush Length (Diameter) X**, **Brush Length (Diameter) Y** and **Brush Length (Diameter) Z** boxes. The brush size is given in voxels.

   The brush shape can be a **Box**, with the side lengths entered in Brush Length X, Y, and Z, or a **Sphere** (Ellipsoid) with the diameters entered in Brush Diameter X, Y, and Z.

   The Material ID of the material to draw with is chosen from the **Material ID** pull-down menu.

   The choice of **Brush Mode** in the pull-down menu determines the working technique for the brush. With **Set**, the selected material replaces the original material. With **Add** and **Subtract**, material is added to or subtracted (removed) from the original material. With **Replace,** material of a selected ID is replaced by a new material.

   The Draw Mode defines whether the brush stroke is applied for **Continuous** drawing, for a **Single Click** or for drawing a **Straight Line**.

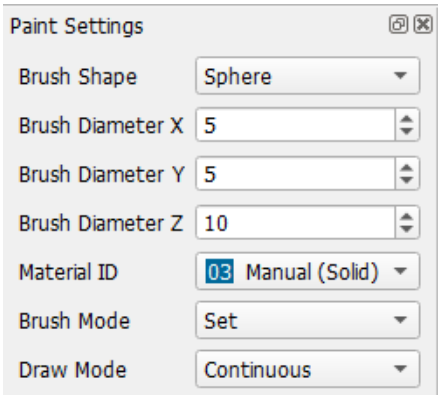


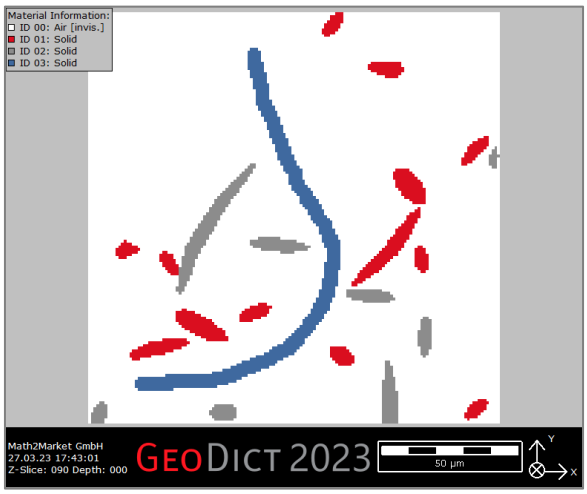
4. The brush strokes, in the selected shape, size, and Material ID (here Sphere (Ellipsoid), diameter 5 x 5 x 10 voxels, Material ID 03), are applied by pressing and moving (for **Continuous Drawing** and **Drawing Straight Lines**) and by clicking (for **Single Click Drawing**) with the left mouse button in the desired position.

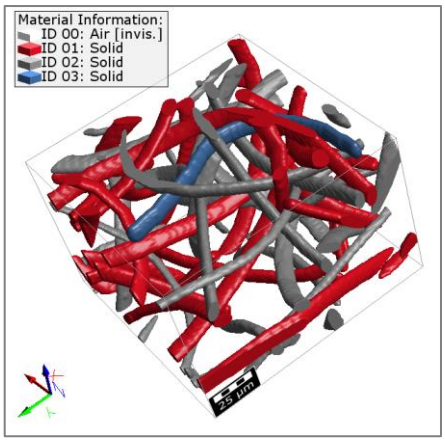
   Strokes at different spatial locations are applied by selecting a different **Direction** (X, Y, or Z) and/or a different **Slice** in the Visualization panel, above the Visualization area.

   The effects of editing (in 2D view) are observed as soon as the left mouse button is released. Here, voxels of material ID 00 have been replaced by voxels of Material ID 03, which are blue. After editing, close the **Paint Settings** dialog and switch to 3D rendering.

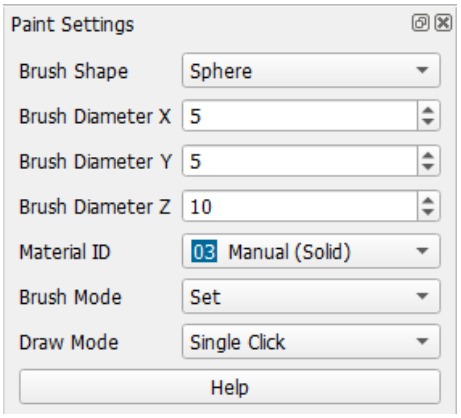
For **Draw Mode Continuous**, press the **left mouse button** while dragging the mouse. Moving the mouse too fast results in an irregularly dashed line.

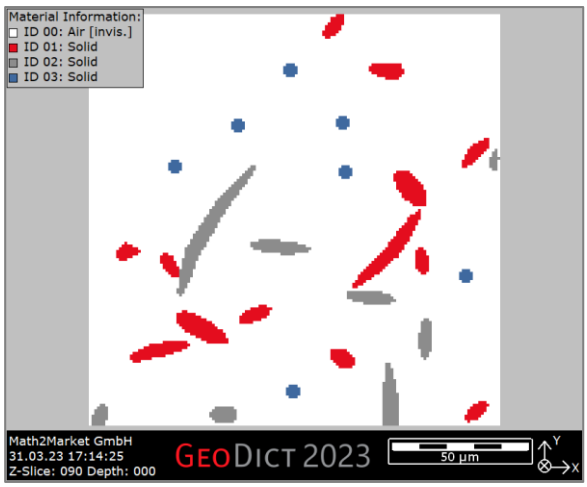


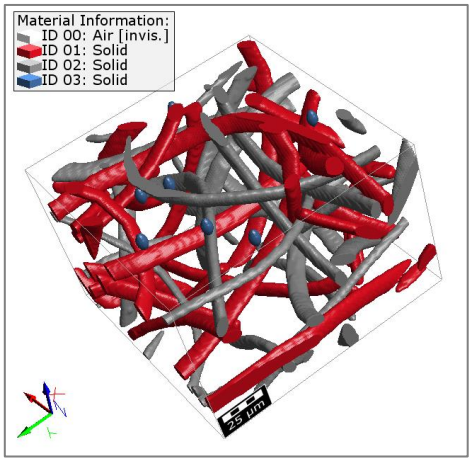




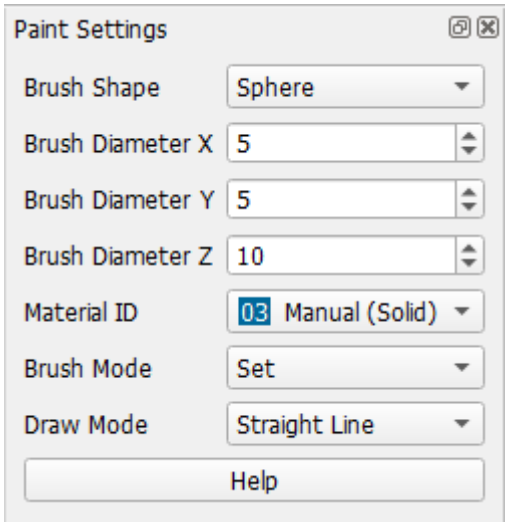
Use **Draw Mode Single Click** by clicking the left mouse button in different locations of the 2D view of the structure model. The effects of editing (in 2D view) are observed as soon as the left mouse button is released. After editing (in 2D view), close the Paint Settings dialog and switch to 3D rendering.

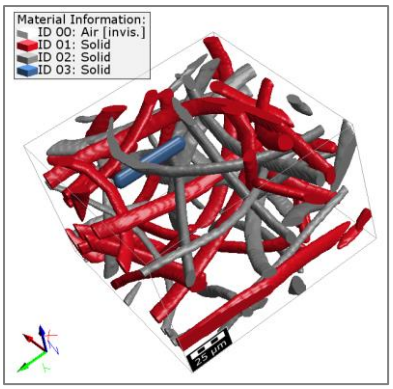






Use **Draw Mode Straight Line** by clicking the left mouse button and drawing the line to the desired end point while holding the mouse button clicked.

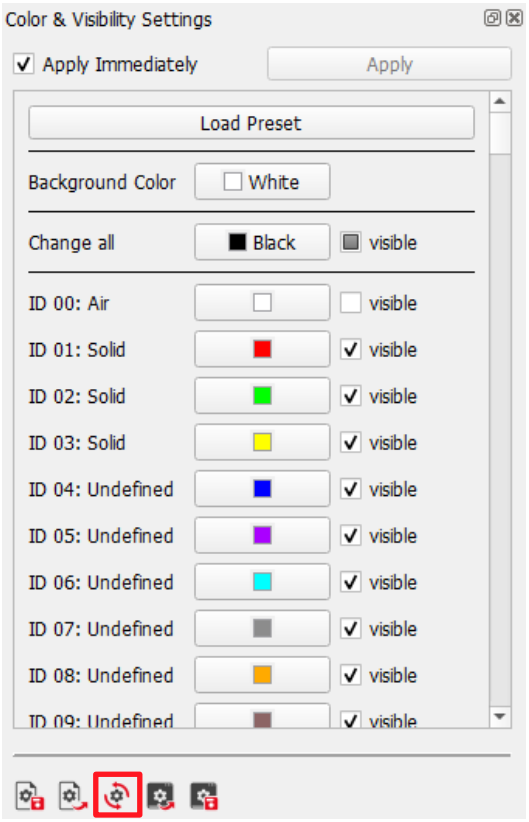




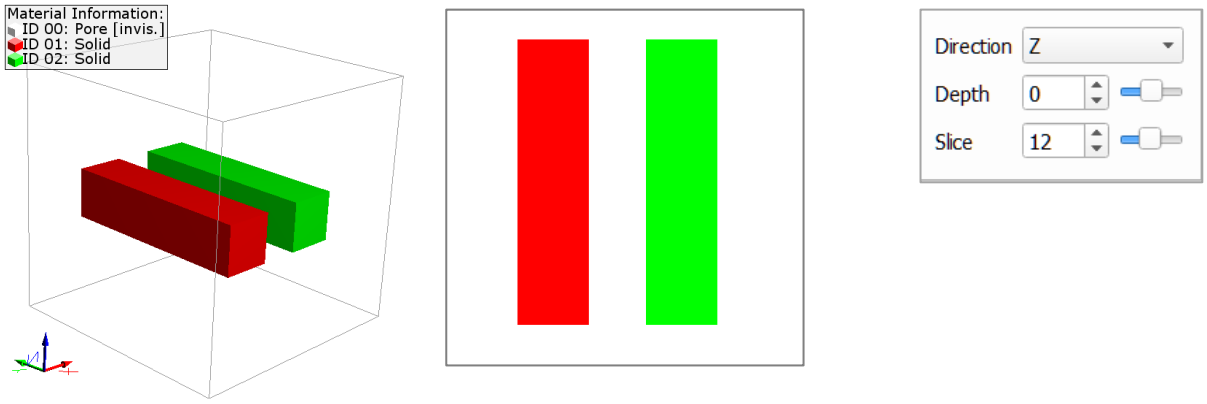
The brush modes **Set**, **Add**, **Subtract** and **Replace** may be selected from the pull-down menu **Brush Mode**. When using Add or Subtract, material intersections occur, where the Material ID of the addition or the subtraction is given by adding or subtracting the binary numbers of the Material ID codes column-wise. This is shown in the next example and explained below on page 71 ff. in more detail.

In the following example, to better observe material intersections, the GeoDict built-in red-green-yellow-blue color scheme is used.

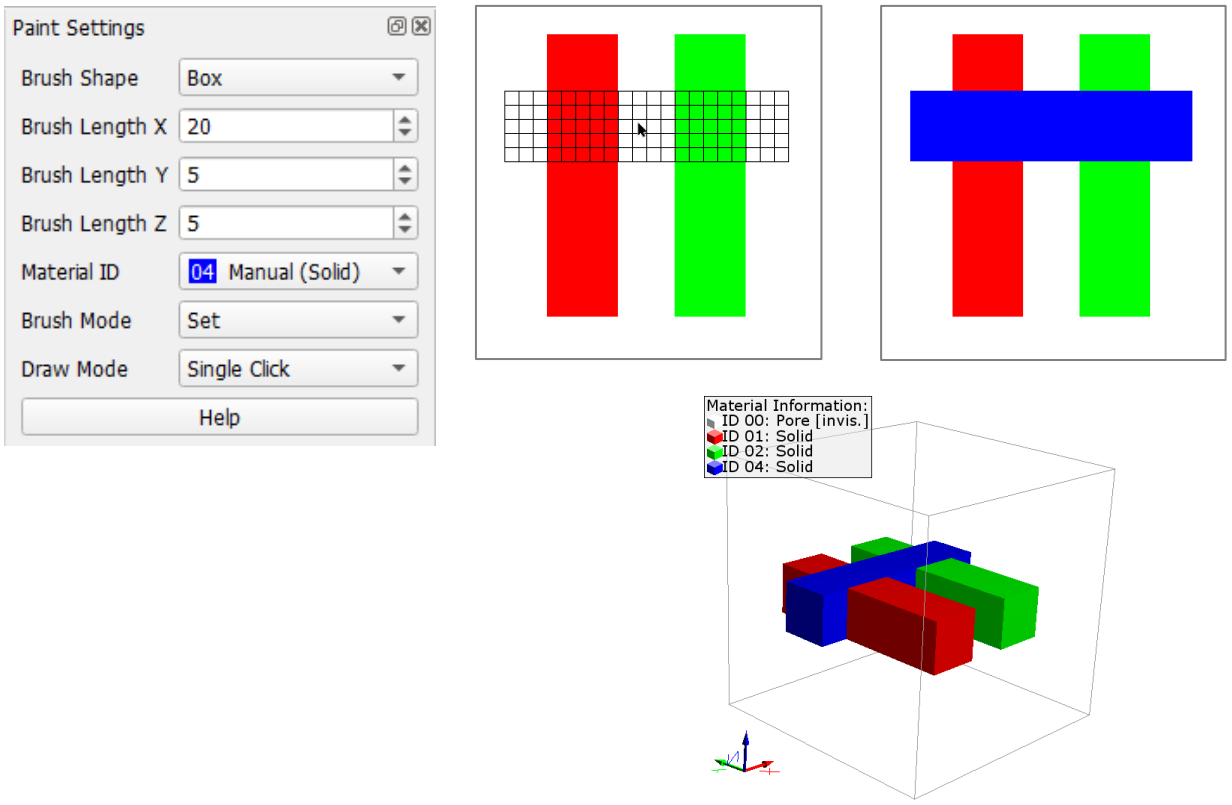
This color scheme is obtained by selecting **Settings → Color & Visibility Settings...** and clicking the  icon at the bottom of the dialog (**Load built-in default settings**).



For this example, two slabs were created with 5x20x5 voxels each. The painting is done in the X-Y-plane on slice 12.

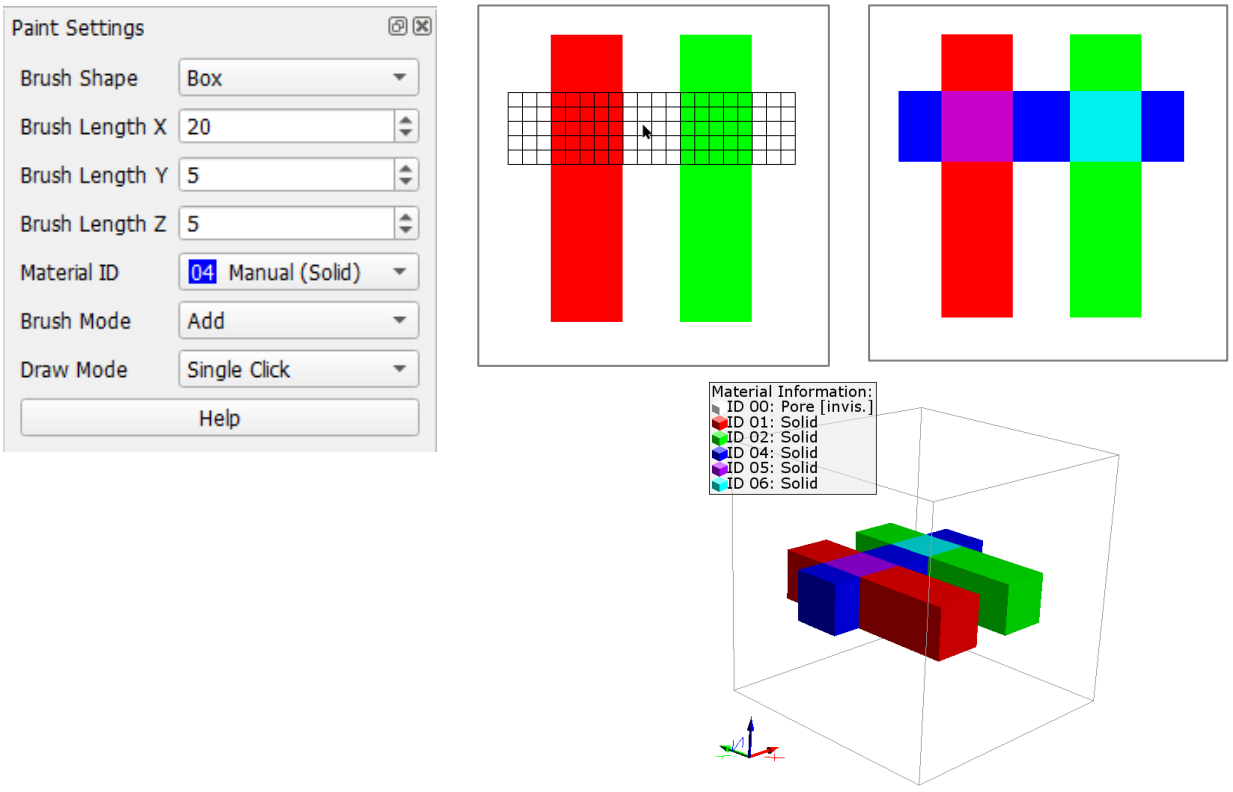


In **Set** mode, the chosen Material ID completely fills the voxels, so that original materials are replaced. The replacement of material is clearly seen in 3D rendering:

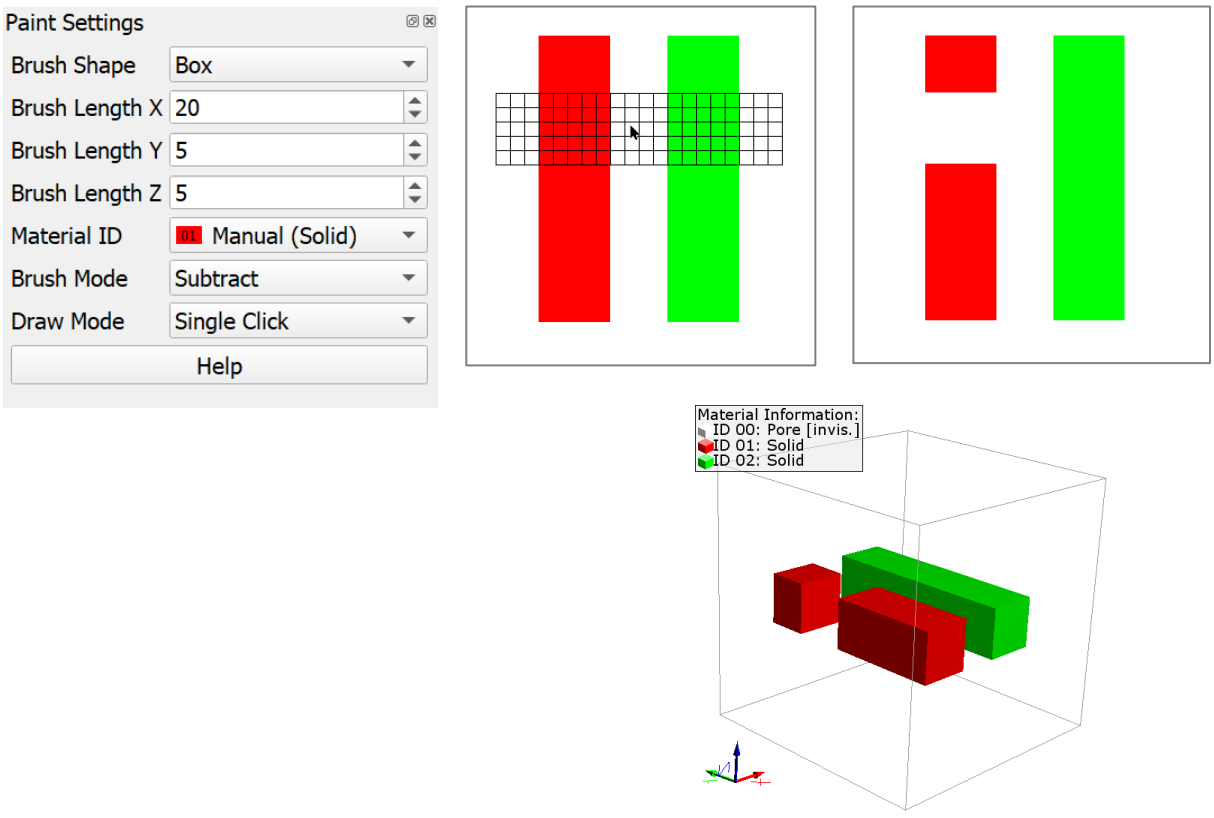


In **Add** mode, the selected Material ID does not fill the voxels, but an intersecting material is built.

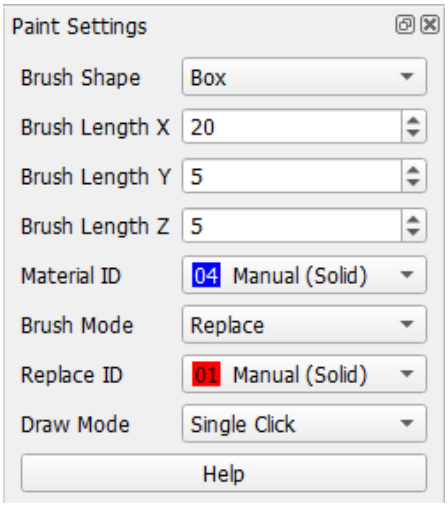
According to GeoDict's rules on defining new material IDs for intersecting materials (see below on page 71), adding voxels of material ID 04 (blue) to material ID 01 (red) results in intersected voxels of material ID 05 (violet-colored). Material ID 04 added to material ID 02 (green) results in intersected voxels of material ID 06 (cyan-colored). And Material ID 04 added to Material ID 00 (porous space) results in Material ID 04. The intersecting materials are also shown below in 3D rendering.

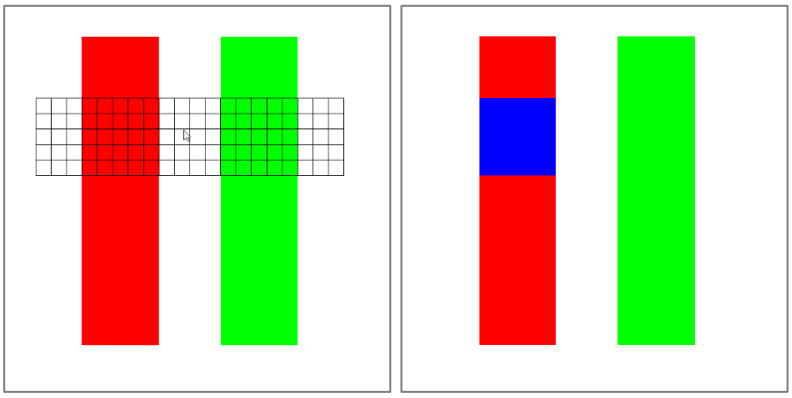


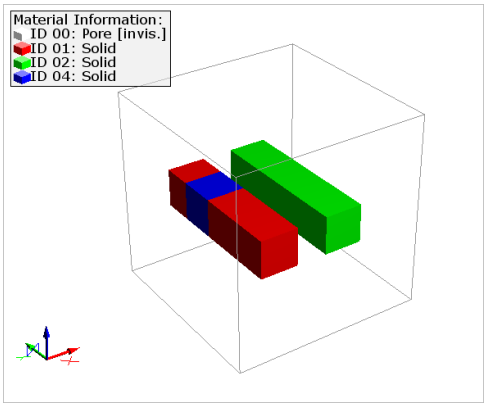
In **Subtract** mode, the selected Material ID is bit-wise subtracted from the existing structure where the brush is applied (see below page 71).



In **Replace** mode, the selected Material ID replaces the Replace ID, not selected Material IDs are unaffected by the modification.







Intersecting Material IDs for Add and Subtract Modes

With the GeoDict built-in color settings, 256 Material IDs are available.

In **Add** and in **Subtract** edit mode, when two materials are added or subtracted, the Material ID of the addition or the subtraction is given by adding or subtracting the binary codes corresponding to the Material IDs. The used calculation rules are shown below.

Binary addition rules				
1	+	1	=	1
1	+	0	=	1
0	+	1	=	1
0	+	0	=	0

Binary subtraction rules				
1	-	1	=	0
1	-	0	=	1
0	-	1	=	0
0	-	0	=	0

The addition or subtraction of Material IDs is done column-wise, as follows:

0	0	0	1	01
+	+	+	+	+
0	0	1	1	03
=	=	=	=	=
0	0	1	1	03

0	0	0	1	01
-	-	-	-	-
0	0	1	1	03
=	=	=	=	=
0	0	0	0	00

Examples of Material ID and binary codes of intersection materials obtained by adding:

First material		Second material		Intersection material	
Material ID	Binary code	Material ID	Binary code	Material ID	Binary Code
02	0010	04	0100	06	0010 + 0100 = 0110
03	0011	04	0100	07	0011 + 0100 = 0111
03	0011	05	0101	07	0011 + 0101 = 0111
05	0101	01	0001	05	0101 + 0001 = 0101

Examples of Material ID and binary codes of intersection materials obtained by subtracting are:

First material		Second material		Intersection material	
Material ID	Binary code	Material ID	Binary code	Material ID	Binary code
01	0001	01	0001	00	0001 – 0001 = 0000
05	0101	02	0010	05	0101 - 0010 = 0101
03	0011	01	0001	02	0011 - 0001 = 0010
04	0100	01	0001	04	0100 – 0001 = 0100

METROLOGY

With the **Metrology** functionality, distances and angles can be measured in the 2D View of a structure.

Select **View** → **2D Cross Section (SEM)** in the menu bar.

Click the **Metrology** tab on the GUI sidebar or click the icon in the toolbar to open the **Measure Angles and Distances** dialog.

In the **Camera** tab of the Visualization panel, choose the **Direction** (**X**, **Y** or **Z**) and the **Slice** of the structure for the measurement.

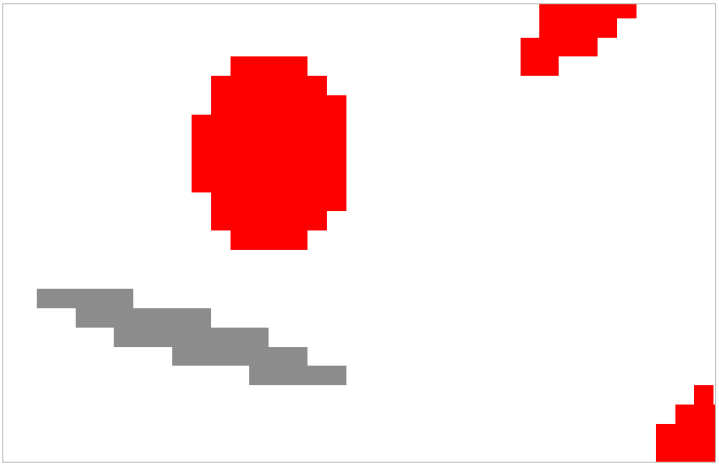
To start a new measurement, first select from the **New Measurement Settings** if a **Distance**, an **Angle** or **Angle and Distance** should be measured.

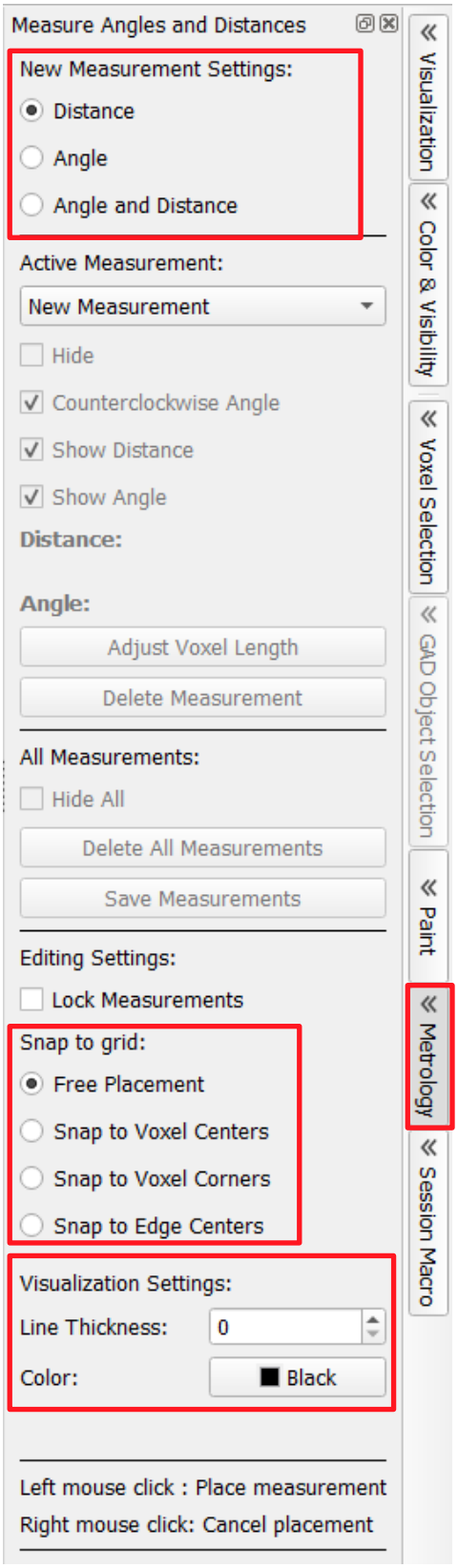
Next, in **Snap to grid**, define if points should be selected freely in the structure (**Free Placement**), or be snapped to the nearest voxel centers, voxel corners or edge centers.

In the **Visualization Settings**, choose the **Line Thickness** and **Color** for the visualization of the measurement.

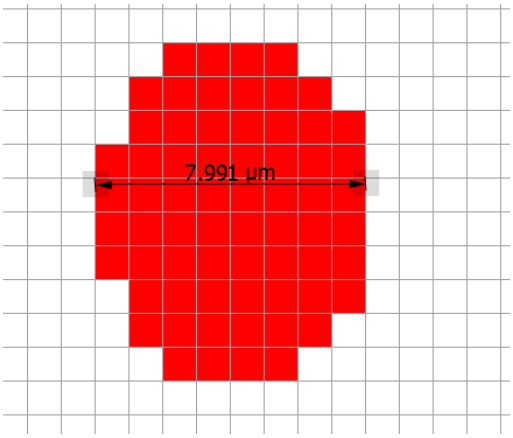
To start measuring, click with the left mouse button at the position, where the measurement should be started and left-click again at the desired end point. If the measurement should be canceled, just click with the right mouse button.

In the example shown here, the diameter of the red fiber in X-direction is measured.

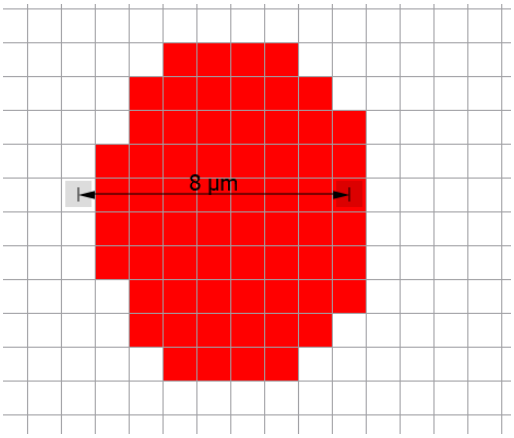




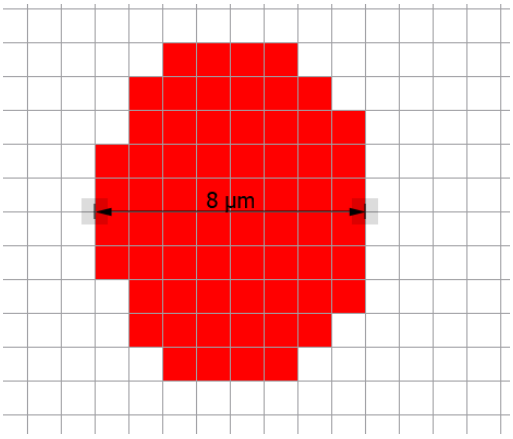
The differences between the snap options can be observed if the visibility of the grid is turned on.



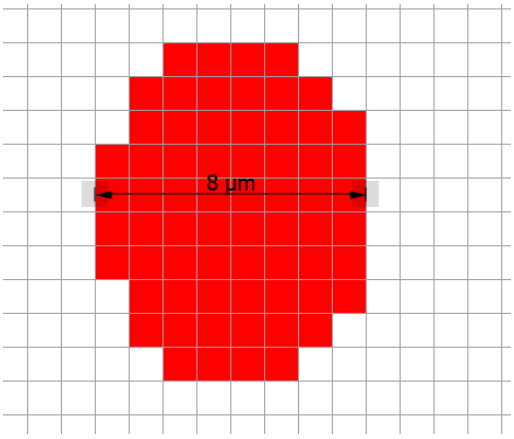
Free Placement



Snap to Voxel Centers



Snap to Voxel Corners



Snap to Edge Centers

For the **Active Measurement**, the measured distance and/or measured angle is shown.

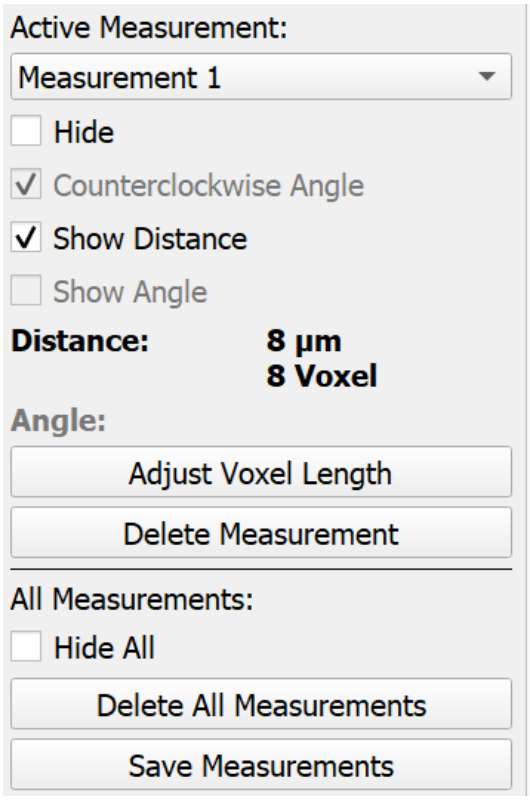
Check **Hide** to hide the measurement and the text in the visualization area, or uncheck **Show Distance**, to hide only the text.

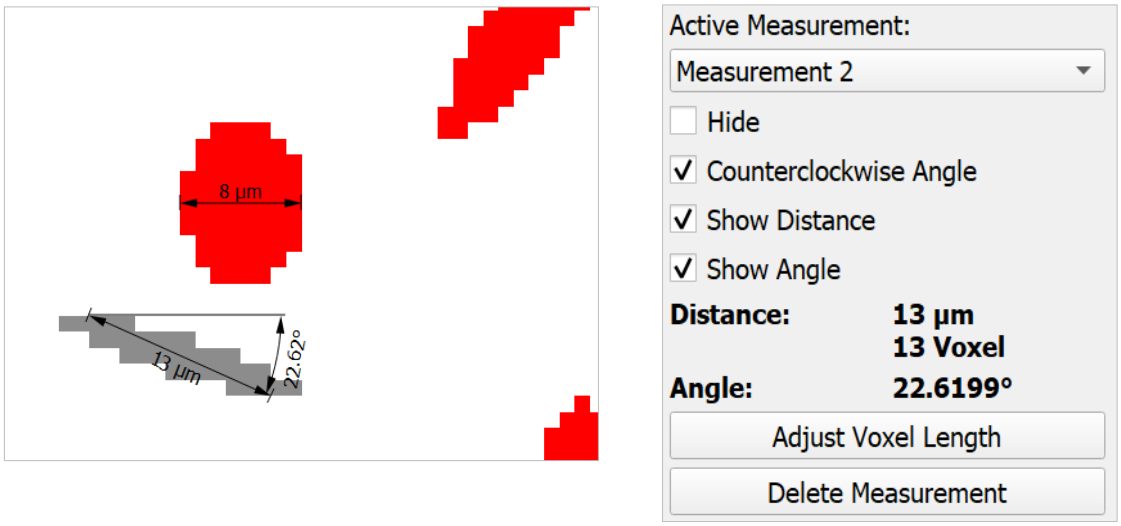
With **Delete Measurement**, the measurement currently active is deleted from the panel.

These options are especially helpful when several measurements are available in the panel.

Create e.g., a second measurement, measuring the length of the gray fiber segment and its angle to the X-axis. For this, set the options for this new measurement to **Angle and Distance**. As snap mode **Snap to Voxel Corners** was chosen.

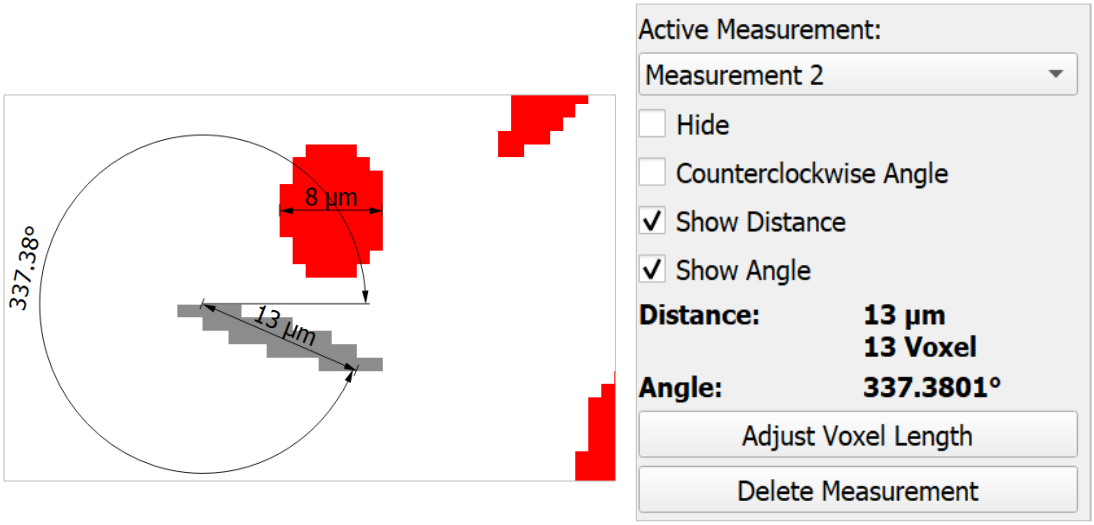
First, the desired distance is measured, then this measure line is taken as first angle leg and the angle can be measured with a third click.



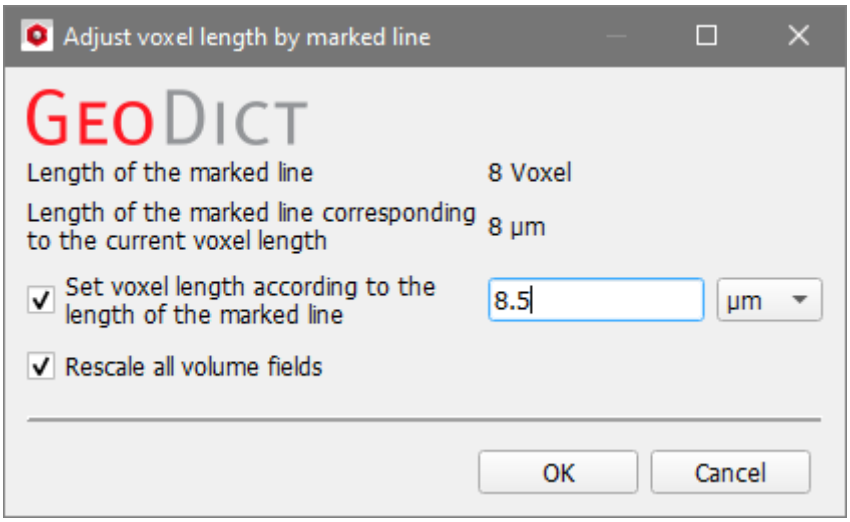


Uncheck **Show Angle** to hide the text next to the measured angle.

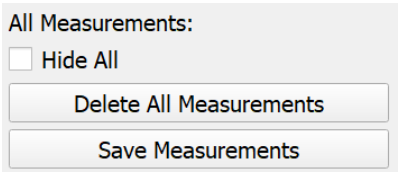
The angle of the segment is shown counterclockwise, as long as **Counterclockwise Angle** is checked.



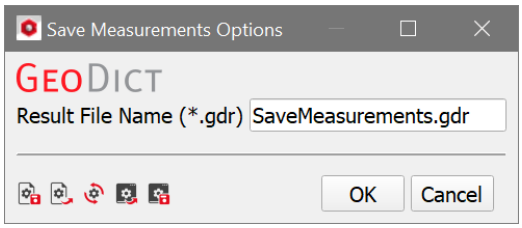
Clicking **Adjust Voxel Length**, opens a dialog to change the voxel length of the structure accordingly to the measured line. Enter the desired length of the measured line (in the example 8.5 µm instead of the 8 µm measured in Measurement 1) and click **OK**. The voxel length of the whole structure is rescaled to match the desired length. Check **Rescale all volume fields**, to rescale also the volume fields to the new voxel length.

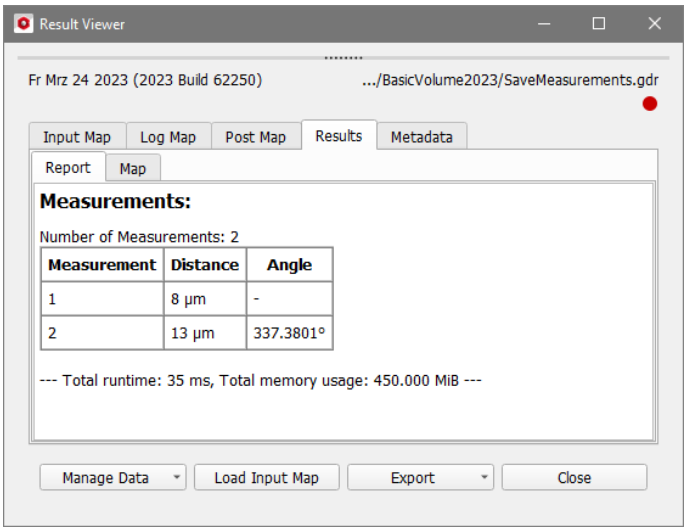


In the **All Measurements** part of the panel, all available measurements, can be hidden by checking **Hide All** or deleted with **Delete All Measurements**.

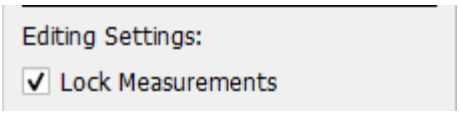


The measurements can also be saved in a *.gdr file by clicking **Save Measurements**. A dialog opens, where the desired result file name can be entered.





Choose **Lock Measurements** in the **Editing Settings** part of the panel to move the whole line of a measured distance and/or angle to another location. If **Lock Measurements** is unchecked, the end point of a measurement can be modified.

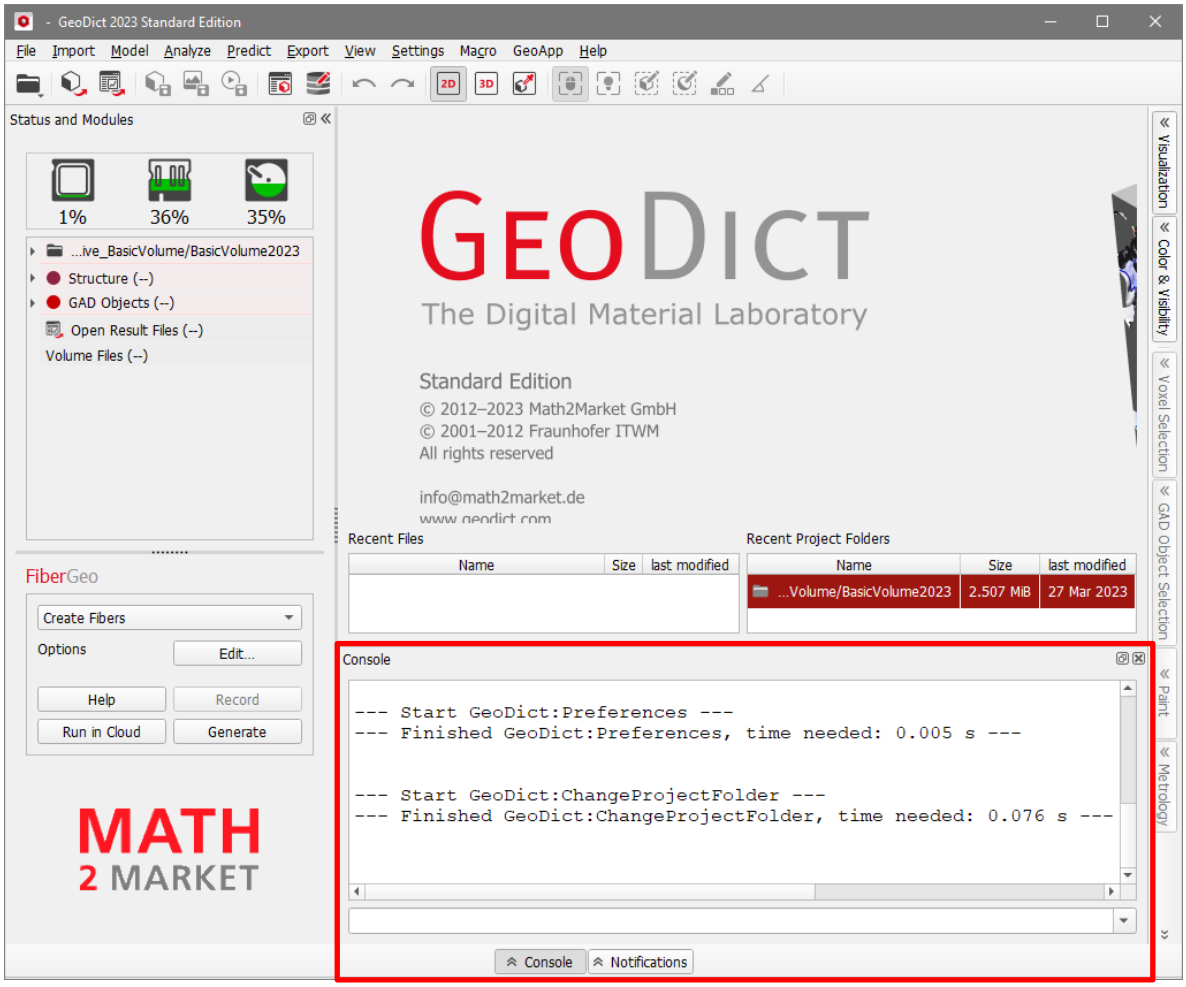


Console and Notifications

The console and notifications panels are located at the bottom of the GUI, under the visualization area. The **Console** panel is a textual GUI window and log viewer. The console allows to read the system logs, help find certain ones, monitor them, and filter their contents. Additionally, the user can enter and execute python commands directly in the console (for more details, see the Automation by scripting handbook of this User Guide).

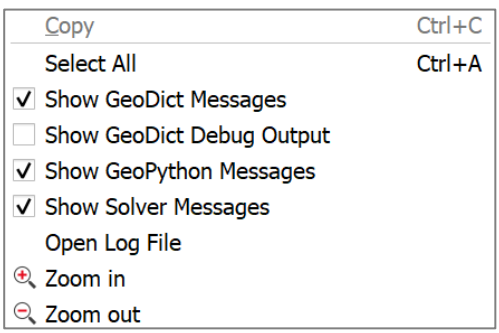
The console panel can be folded and unfolded by clicking on the Console icon.

When expanded, the panel can be un-docked and turned into a dialog that can move around. Undocking is done by clicking the icon, located at the top right after expanding. The console can also be closed by clicking on .

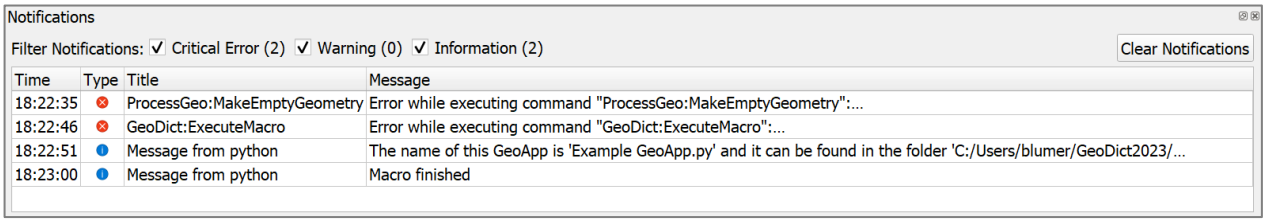


The **Notifications** panel is new in GeoDict 2023 can be opened and closed in the same way by clicking on the Notifications icon.

A right click in the console panel provides further options to filter and read the information displayed. Text in the console can be marked with the cursor and exported to another program by using **Copy**. With **Select All** the whole text in the console is marked.



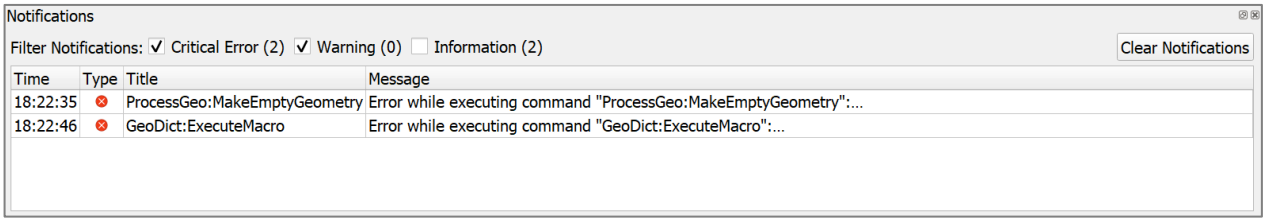
Check the boxes to **Show GeoDict Messages**, **Show GeoDict Output**, **Show GeoPython Messages** and **Show Solver Messages**. During each GeoDict session a log file, that contains all outputs from the console, is written and saved in %username&/geodict2023/log (Windows) or %username%/.geodict2023/log (Linux). With **Open Log File** it is opened in the chosen text editor (see page 22 ff.). Use **Zoom in** and **Zoom out** to enlarge or reduce the font size of the console.



Messages from GeoDict, which are shown in the console, are also shown in the **Notifications** panel.

The list shows the **Time**, when a message was raised, the icon shows the **Type** of the message, also the **Title** and the **Message** itself are given. With a right click in the corresponding field the title and the message text can be copied to the clipboard to save them e.g. in a text editor. This can be helpful, if a message boxed was closed and the user wants to re-read the message. Another advantage is, that the user does not have to scroll through the console, where other output from GeoDict is listed.

With the filter options it is possible to show only **Critical Errors**, **Warnings** and/or **Information**. With **Clear Notifications** all messages from the list can be deleted.



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