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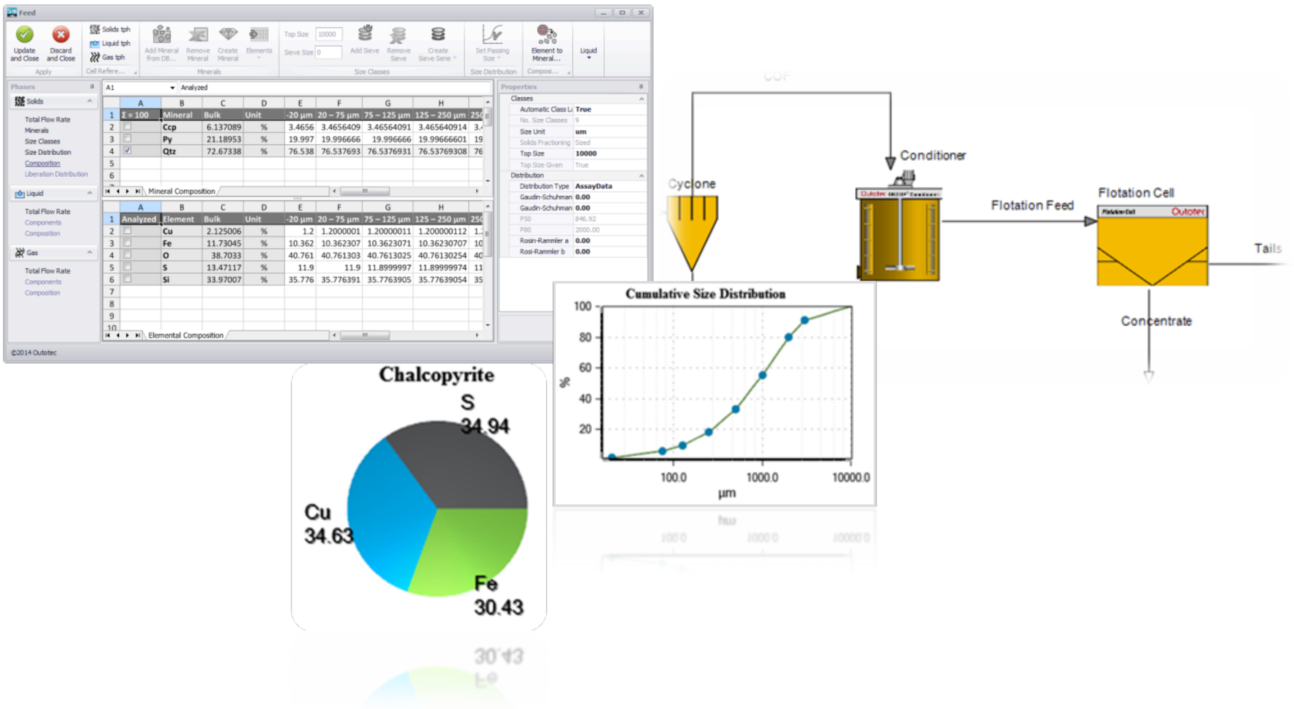
45. Sim Minerals Processing



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45.1. Introduction

45.1.1. Particle-based modeling

HSC Sim has a special set-up and approach for processes where minerals are treated. This approach should be used for processes such as crushing, grinding, flotation, gravity separation and screening. Mineral-based models treat particles that have at least the following properties:

- size (diameter)
- mineral composition in wt.%

In addition, they may have additional parameters like composition by volume%, mineral composition by surface area%, whiteness, hardness, etc. Each mineral has a certain chemical composition and specific gravity on the basis of which HSC will calculate these properties for each particle and also for each stream. **Fig. 1** illustrates the solids phase set up as a particulate material - the approach HSC Sim minerals processing models are based on.

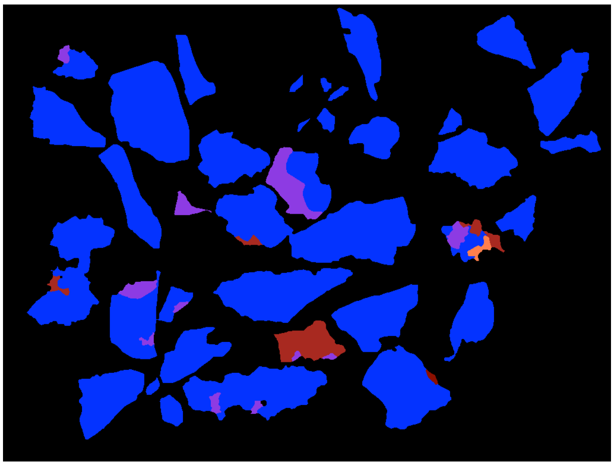


Fig. 1. Particles of different sizes, consisting of one or more minerals. A colored SEM (Scanning Electron Microscope) graph (Outotec Research, Pori, Finland).

HSC Sim supports a versatile set-up of the particle-based feed streams, according to the desired modeling complexity. Each mineral can be a fully liberated material that can be further be divided into several size classes with particles in them. With a more elaborated feed set-up, the degree of liberation and association between different minerals in each size class can be defined. **Fig. 2** gives examples of different particle set-ups: liberated (100% one mineral), binary (two minerals), ternary (three minerals), and complex (four or more minerals); all of these are possible in HSC Sim.

The feed composition and mineralogy are defined with the HSC Sim Stream Setup tool complemented by HSC Geo's extensive mineral database, mineralogical calculation tools, and MLA (Mineral Liberation Analysis) data file importing and handling possibilities.

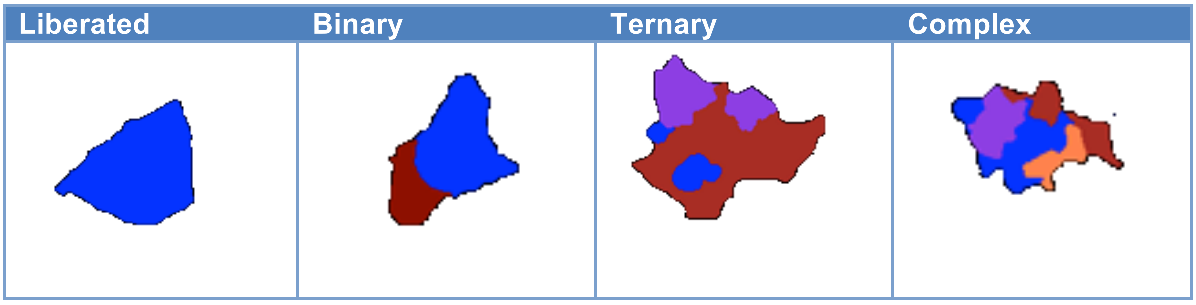


Fig. 2. Different complexities of minerals according to their liberation.

HSC Sim assigns several properties to each particle. A stream consists of a certain ton per hour amount including that particle type. All the stream properties, such as the element wt% in it, solid specific gravity, or total solids tons per hour, for example, are always calculated based on the particle composition of the stream. The particle properties and most common stream properties are listed below. These stream properties are also at the same time the initial data for setting up a feed stream for which the particles are automatically generated.

1. Particle properties

Each particle has its own specific properties that are set when they are created, e.g. in the feed Stream Setup. They consist of:

- A list of minerals, their composition% in a particle and properties including:
  - ✓ Name
  - ✓ Code (name shortening)
  - ✓ Chemical formula
  - ✓ Specific gravity
  - ✓ Chemical composition
  - ✓ *Optional: Database reference*
  - ✓ *Optional: additional properties (user-defined)*
- Size class information including:
  - ✓ Lower and upper boundary of each class and geometric average
  - ✓ Name label of the size class
  - ✓ Optional: number of particles in a class, in case of MLA file imported particles
- *Optional: particle floatability parameters for flotation kinetics based separation*
- *Optional: particle type, indicating its mineral association group, typically with MLA file imported particles.*

2. Stream properties (feed)

Streams consist of numerous properties and calculated values derived from their particle composition. The feed stream particles are generated by HSC Sim based on the following data:

- Total solids input of the stream (t/h)
- Weight percentage of each size class (totaling 100%)
- Weight percentage of each mineral in each size class (totaling 100%) and in bulk (calculated)
- Chemical composition of fractions and bulk (calculated)
- *Optional: mineral liberation and association data for each size class. Only if non-liberated particles are to be set up and used in modeling.*

Particle handling in process units:

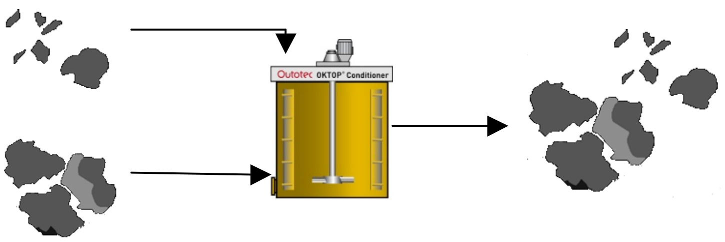
When a stream is directed to a certain unit in a flowsheet, the particular unit operation of that unit can treat the particles as follows:

1. Mix the particles of all the incoming streams and direct the mixture to one or more outputs.
2. Break down the particles. This is the only unit operation where (some of) the incoming particles are destroyed and do not exist in the output. Instead, new particles are generated so that the total flow rate and mineral balance are held over the unit.
3. Particles can be separated according to several properties; typically: size, specific gravity, mineral composition (resulting in the overall flotation kinetics for that particle, for example), etc…

The above main particle stream phenomena and examples of the unit operations for these are shown in **Fig. 3**.

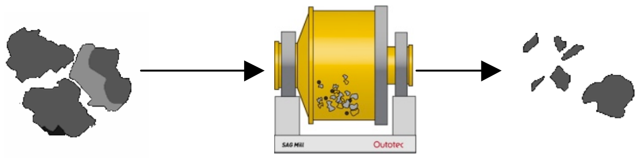
Mixing

- **Pump sump**
- **Feed box**
- **Mixing tank**
- **…**



Breaking Down

- **Crushing**
- **Grinding**
- **…**



***Separation*, by**

- **Size (e.g. screening, hydrocyclones)**
- **Specific Gravity (e.g. Knelson concentrator, hydrocyclones)**
- **Mineral Composition (e.g. flotation)**
- **Shape, Color, etc…**

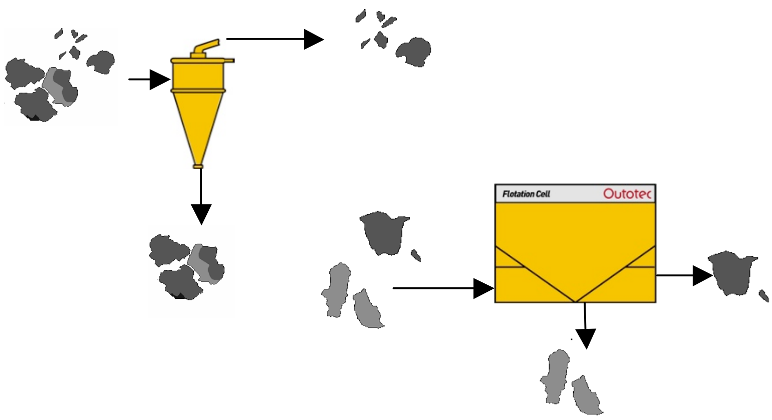


Fig. 3. Examples of unit operations based on the stream particles.

45.1.2. Levels of modeling detail

Before starting to build up HSC Sim minerals processing models it is worth considering how much detail is required, what background data are available, and what type of unit models are available with what level of detail. **Fig. 4** illustrates how the feed material can be defined and thus how the unit models should be capable of handling stream compositions.

In addition to increasing the level of detail, the number of particles transferred between the units increases. With large simulation models this might have impact on the simulation calculation speed (especially in the case of dynamic simulation). Also, quite often increasing the modeling details means increasing the time needed to build up and parameterize the simulation model. **Fig. 5** lists some of the minerals processing application areas where different details of modeling are typically applied.

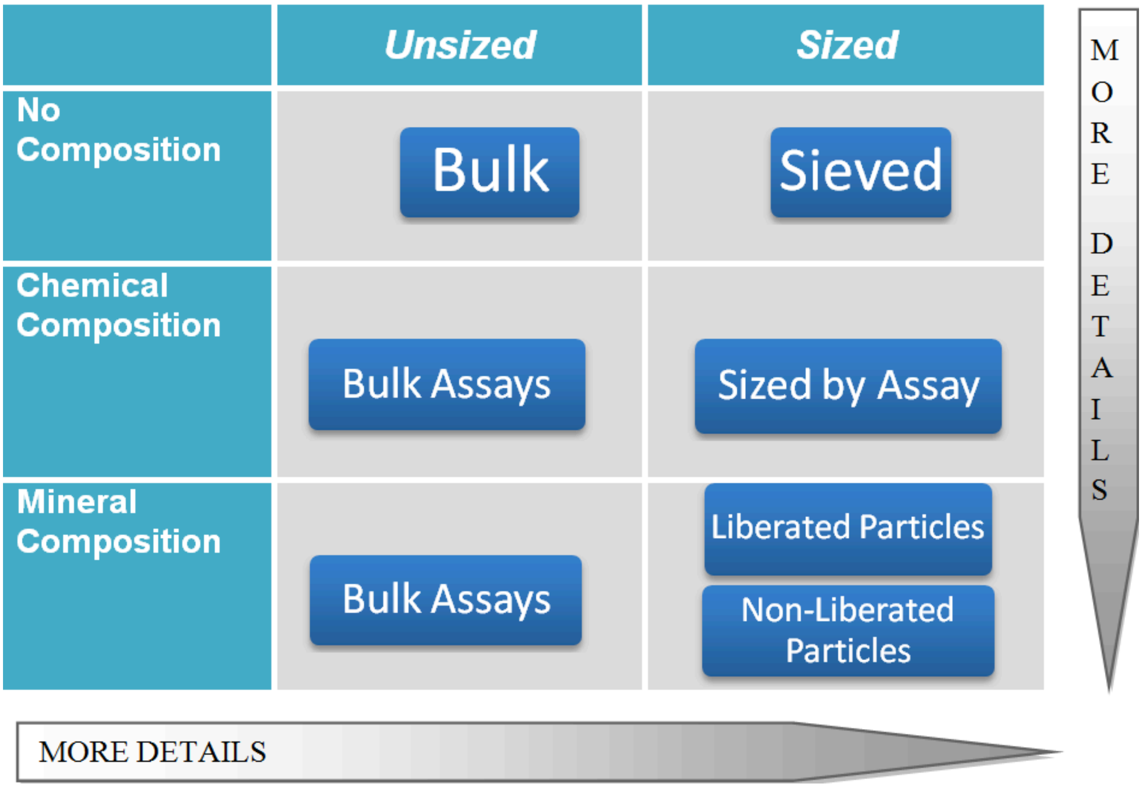


Fig. 4. Levels of modeling detail – required background data.

	Unsized	*Sized*
No Composition	▪ Simple Material t/h Balance	▪ Crushing ▪ Grinding ▪ Screening ▪ Cyclones ▪ Etc...
Mineral / Chemical Composition	▪ Bulk Material: ▪ Flotation ▪ Physical Separation ▪ Etc...	▪ Sized Particles: ▪ Flotation ▪ Physical Separation ▪ Comminution ▪ Etc... ▪ *MLA Based Particles Modeling*

Fig. 5. Levels of modeling detail – examples of modeling application areas.

45.1.3. Minerals processing flowsheet structure in HSC Sim

The HSC Sim process flowsheet consists of Units and Streams (**Fig. 6**). When the modeling is based on particles, a ***Stream*** consists of ***Solids*** and ***Liquid*** and ***Gas*** phases, although the gas phase is rarely set for a mineral slurry feed stream. The liquid may have soluble components, but in minerals processing, these species are often ignored, i.e. the liquid (water) only has density as a parameter. Solids consist of particles which are composed of minerals. Minerals have properties such as chemical composition. In HSC Sim all the properties of solids are calculated from particle flow rates, particle compositions, and mineral properties. For example, copper does not behave independently in the process but is always bound to a mineral or minerals that occur in particles, which vary in size and composition.

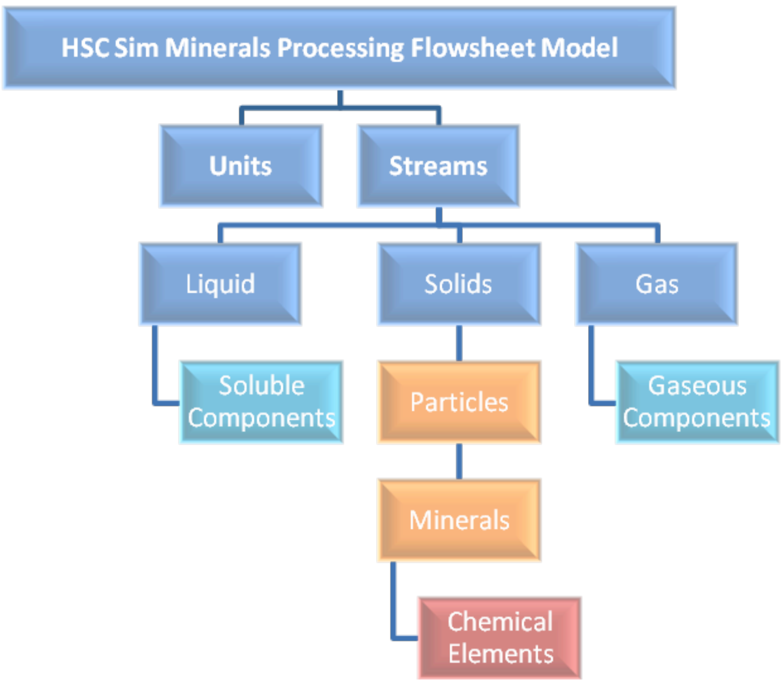


Fig. 6. Structure of HSC Sim flowsheets for minerals processing.

45.1.4. HSC Sim file structure

HSC Sim flowsheet models must always be *saved in a separate folder*, each of them. This is because the same file names may exist in the flowsheets, and they must not be mixed between flowsheets. The folder name can differ from the flowsheet name; they are not related to each other. The process flowsheet model is in a ***Sim8*** file, and can be opened in HSC Sim 8 by double-clicking it. **Table 1** summarizes the simulation model files located in the model folder.

NB: A flowsheet model can be copied or sent elsewhere just by sending (zipping) the whole simulation model folder.

Table 1. HSC Sim files in minerals processing flowsheet models.

Model Component	Corresponding Files	What They Are
Flowsheet	ProcessName.**Sim8** ProcessName.**Sim8bin**	▪ Flowsheet layout description ▪ Unit icons, data, etc. related to the flowsheet
Unit	Unit_1.**xlsx** Unit_2.**xlsx** Unit_N.**xlsx**	▪ Each unit has a separate file to store its parameters, state and settings
Feed Stream	Feed_1.**HSCStream** Feed_2.**HSCStream** Feed_N.**HSCStream**	▪ Each feed stream has a separate file to describe the (particle) feed composition

45.1.1 Before starting to create a simulation model

Before starting to build a process for simulation, you should collect all the relevant data of the process. According to the data and your aims, you should:

1. Decide the level of detail you want to have in the drawing and simulation.

   - Is it necessary to draw all the existing units (e.g. pump sumps), or could the circuit be simplified without losing any essential information?
   - It is a good idea to draw a draft of the flowsheet on a piece of paper. That will help you to position the units correctly.

2. Decide the level in terms of particles. The possible levels from the lowest (least information) to the highest are:

   a. __**Sized model without composition**__. Typically grinding circuits are modeled like this. The chemical and mineral composition of the input (e.g. ROM) is identical to the output (e.g. flotation feed), and the main interests are in flow rates and the required energy. (Typically 5-25 particles)
   b. __**Unsized mineral model**__. Each mineral is treated separately but all the size classes are treated together. Typically a simple flotation model is like this. (Typically 3-8 particles)
   c. __**Unsized floatability components model**__. Each mineral is divided into 2-3 floatability classes, (i.e. fast floating, slow floating and non-floating) or several (~20) different classes of floatability distribution (e.g. Klimpel model). (Typically 9-150 particles)
   d. __**Size-by-mineral model.**__ Each mineral is treated (Typically 15-

	separately by size. This approach enables the simulation of a full mineral processing circuit including crushing, grinding, classification, and different kind of separation techniques like flotation, gravity separation, magnetic separation, and dewatering.	300 particles)
e.	**<u>True particles model.</u>** This is the highest level of modeling where particles treated in the process have been measured with e.g. MLA and all of them or groups formed from them are treated in the process.	(Typically 200-15 000 particles)

Remember that if you go to a higher-level approach you will need more data and better models.

3. List the minerals present in the circuit. Find their chemical composition and specific gravity. If you do not know, please ask a geologist or mineralogist or look for a mineralogical report.

4. Find the chemical composition or mineral composition of the feed streams. If you have only the chemical composition, do the element to mineral conversion (with HSC Geo, together with the Sim Stream Setup tool).

5. Find the flowsheet of the process or if it is a greenfield process, consider possible alternatives and decide where to start.

6. Find data for unit models and their parameters. To create models you will need some experimental data. These are elemental assays from a laboratory test, pilot test, or survey. If you have data, you can organize the data in HSC using the Mass Balance module to mass balance and reconcile data (see Chapter 51 Mass Balance). Some of the simplest models do not have operational parameters like size, length, gap size, volume, or area, but if you want to use more comprehensive models you should gather this information as well.

After obtaining the background data, the <u>building of a simulation model</u> comprises the following main steps:

I. Draw the flowsheet: place the units there, rename them, draw the streams and rename them
II. Check that all the streams are connected correctly
III. If not yet done, next save the flowsheet to a separate folder. Please take backups every now and then
IV. Define the feed streams: feed rate, select minerals, size classes, size and mineral/elemental composition, liquid and gas phases
V. Select and load the unit models and set the parameters and possible controls for them
VI. Simulate and fine-tune the model. View, visualize and report the results.

These steps are described in more detail in the following sections.

45.2. Drawing a flowsheet

45.2.1. Units and unit icons

The process units can be placed by dragging and dropping them from the Unit Icons panel on the right; the library includes several ready-made process device icons. Alternatively, you can just draw a rectangle unit without a figure, by selecting it from the left-side button bar. The unit figure can also be changed and replaced with your own drawing or photograph if desired. Selecting and drawing the unit on the flowsheet are shown in **Fig. 7**.

NB: Unit figures do not contain calculation models, just the graphics to illustrate them on the flowsheet. The calculation model is selected and loaded separately in a later step.

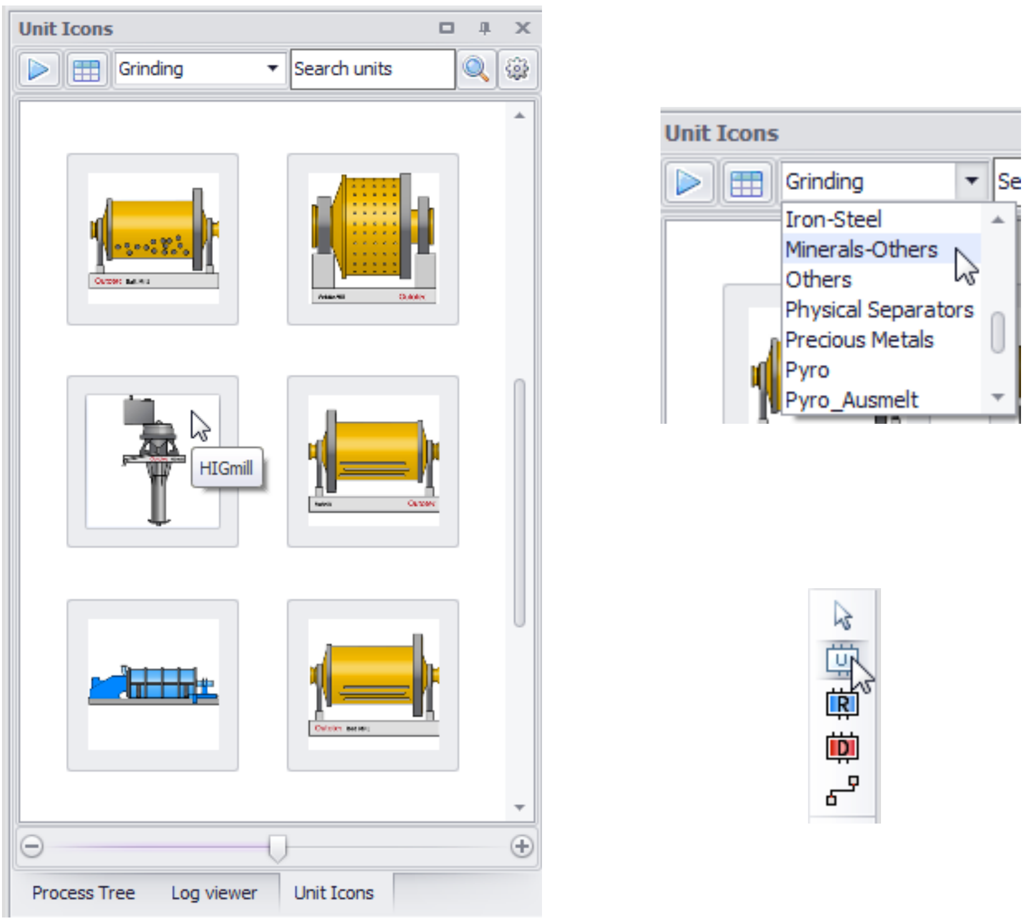


Fig. 7. Unit model icons can be A) dragged and dropped from the HSC Sim library, B) the library folder can be changed from the menu; or C) just a generic unit with a rectangle box icon can be drawn.

45.2.2. Connecting streams

The streams area drawn on the flowsheet by selecting the stream drawing tool from the bar on the left (**Fig. 8**). The streams area is automatically connected to the nearby unit to/from which they are directed. The streams can be redirected and connected elsewhere on the flowsheet; HSC Sim will then ask you to confirm whether the stream source/destination should also be changed (**Fig. 9**). In addition, the source and destination can be set from the stream properties panel on the right (**Fig. 10**).

Fig. 8. Drawing the streams.

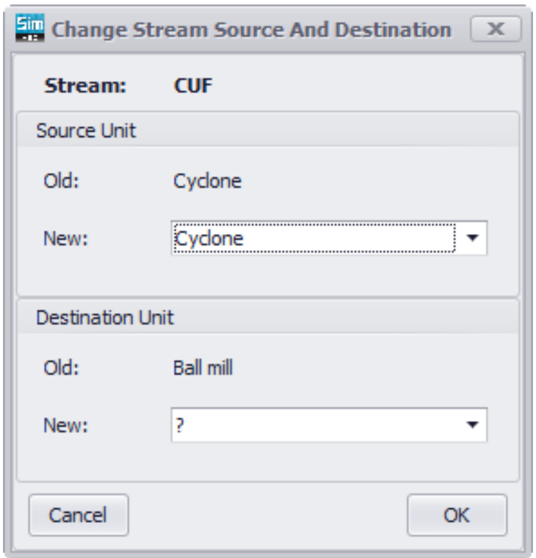


Fig. 9. Setting stream source and destination after redirecting the stream on the flow sheet drawing.

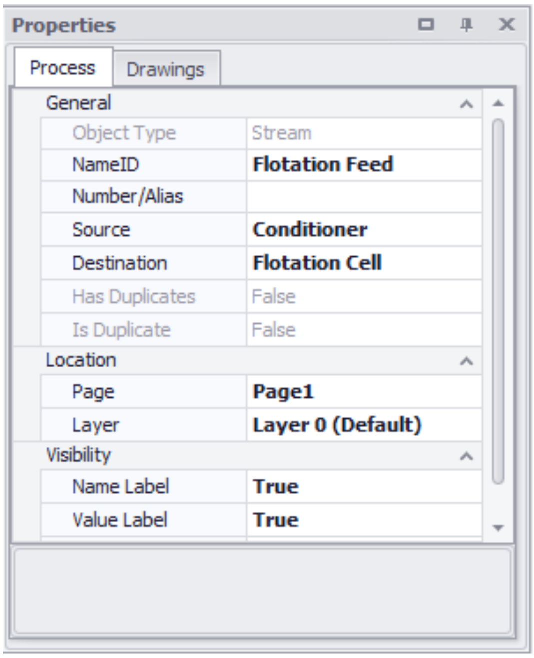


Fig. 10. Stream properties where the Source and Destination can be set.

The streams are renamed by double-clicking the stream name label, or from the stream properties panel. The value labels – showing the simulated values of the selected variable in the visualization mode – are inserted automatically. The stream names and value labels can be modified in terms of font, color, etc. from the properties panel.

45.2.3. Checking the flowsheet

When the flowsheet is ready, you should check that all the stream connections are going to the correct units. The visual notation for the streams is as follows:

- ✓ Starting point = no shape: stream is an output of a unit
- ✓ Starting point = white circle: stream is a feed input to the simulation
- ✓ Ending point = filled arrow: stream goes to an input of a unit
- ✓ Ending point = white arrow: stream is an output of the simulation that does not go to any unit

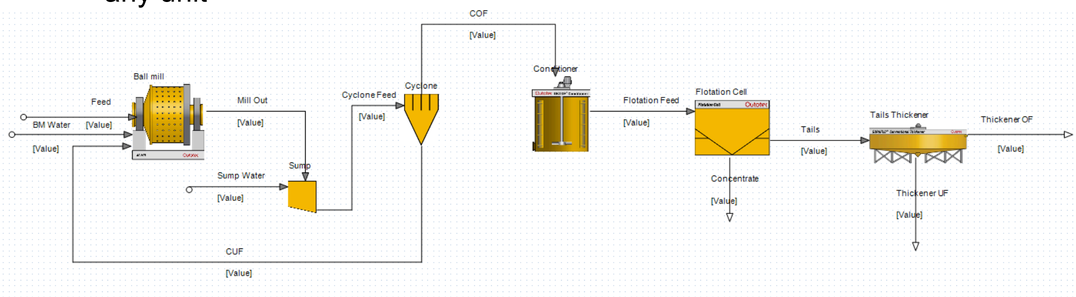


Fig. 11. Example of a flowsheet with units and the streams connecting them.

NB: There is no need to define the stream type as solids/slurry or liquid/water as required in HSC 7. HSC 8 handles all of the streams in the same manner regardless of the stream composition.

When the flowsheet is ready and you have checked it is correct, the feed stream(s) can be defined.

45.3. Stream Setup – Defining the feed composition

Feed Streams for HSC Sim minerals processing models are defined by using the **Stream Setup** tool. To open Stream Setup:

- ✓ Right-click a feed stream and select “Define this stream with Stream Setup”
- ✓ When the stream content is already defined, it can be modified at any time. Open Stream Setup by double-clicking the stream.

The Stream Setup dialog (**Fig. 12**) consists of:

- Upper bar buttons
- Left-side **Phases** navigation tool
- Right-side **Properties** of selected component
- Right-side **Graphs** of selected component
- Middle area for setting up the feed properties

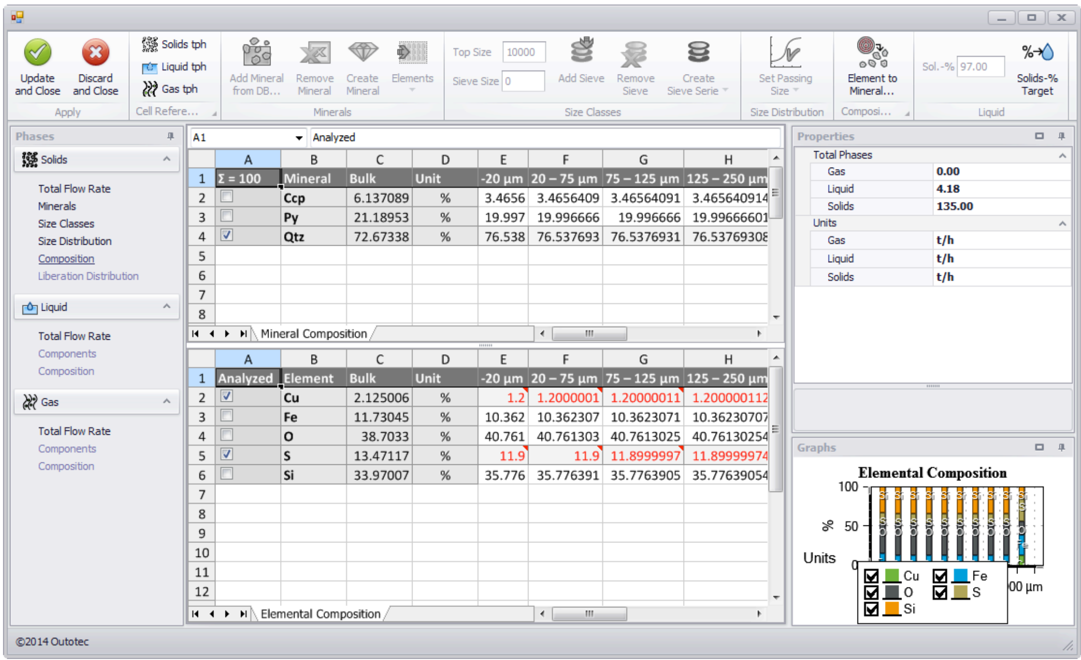


Fig. 12. Stream Setup tool dialog for defining a minerals processing feed stream. The ‘Solids Composition’ view is shown here.

All the required data is entered in the middle part of the dialog, by navigating the steps on the left-side **Phases** navigation panel (**Fig. 13**). The data can be entered in any order, but the easiest way is to follow the links from top to bottom, starting from the Solids Total Flow Rate.

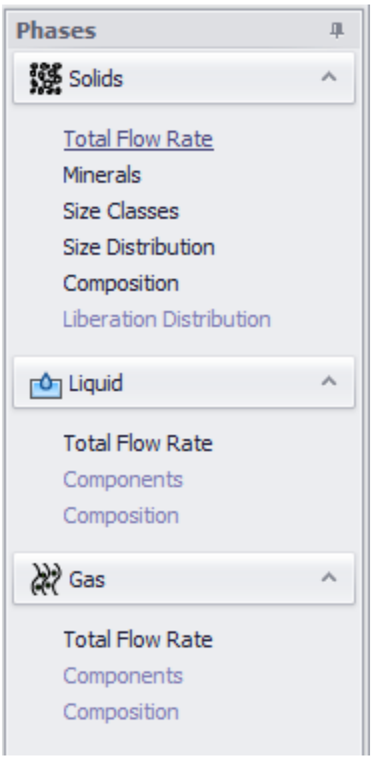


Fig. 13. Phases navigator to set the stream data step by step.

When the desired stream data have been entered, the stream and its particle content are saved and updated to the simulation model by clicking Update and Close on the upper bar (**Fig. 14**). Alternatively, the changes can be cancelled using the Discard and Close button.

The cell references for the total t/h flow rates of the Solids, Liquid and Gas phases can be copied by clicking the respective upper bar buttons. The cell reference can then be pasted and used elsewhere, for example in controls that adjust the flow rates of the feed streams.

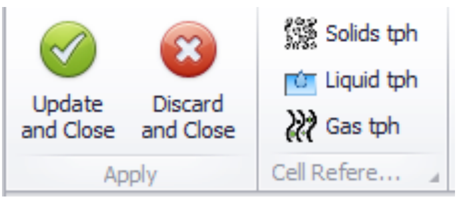


Fig. 14. Buttons to apply changes and to copy cell references for the total phase flow rates.

<u>Good to know:</u>

- ✓ You can always relocate or detach the dialog components as you like
- ✓ Just drag and drop them to undock & dock elsewhere
- ✓ You can leave the dialog components floating on the display and resize them freely
The figures have tools that appear when you place the cursor over them: you can copy, print, clone, etc.

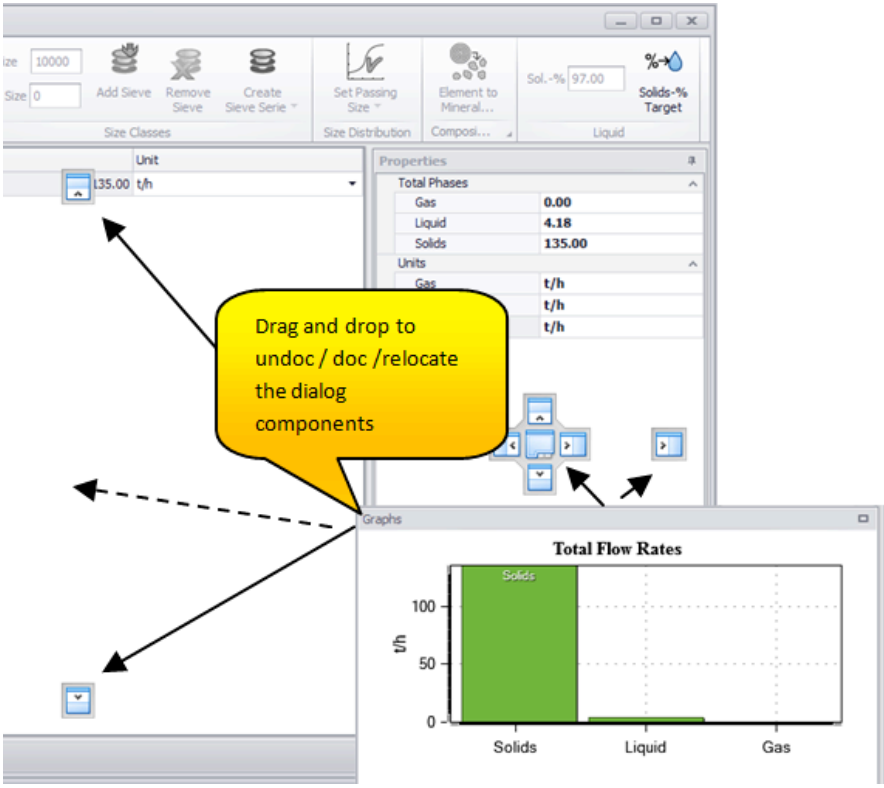


Fig. 15. Relocate and resize the dialog components by undocking and docking them with the left mouse button held down.

45.3.1. Solids feed

Solids feed is based on particles in the HSC Sim minerals processing models (see **Fig. 6**). In the simplest form no size classes (bulk flow) and no minerals are defined (thus the default is bulk 'Ore' mineral). To set up the solids feed composition and mineralogy, the following data need to be defined:

- Total Flow Rate
- Minerals
- Size Classes
- Size Distribution
- Composition of minerals and elements

45.3.1.1. Total solids

The total solids are entered in the Amount field; the unit can be changed from the dropdown menu, and the amount is then automatically recalculated (**Fig. 16**). NB: The unit in this selection does not affect the unit shown in the flowsheet simulation. There the flow rates are shown in t/h.

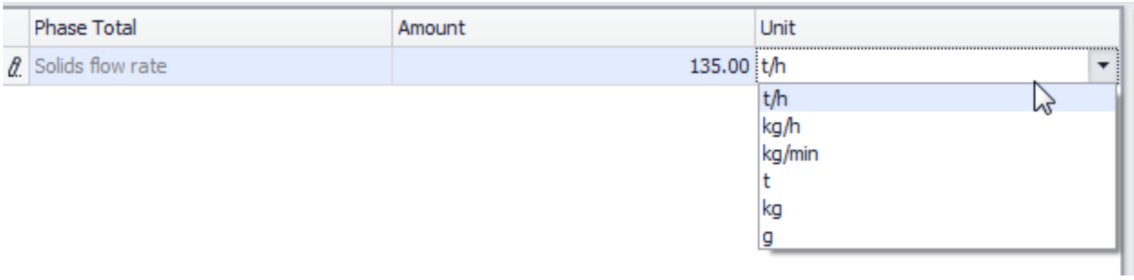


Fig. 16. Setting the total solids flow rate and its measure unit.

In addition, the total phase flows can be entered and the measure units changed in the properties panel on the right (**Fig. 17**).

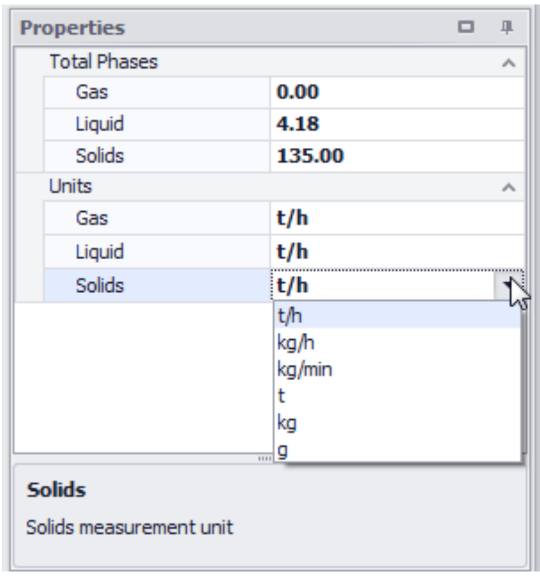


Fig. 17. Properties of total phase flows (in the panel on the right).

The total flow rates are visualized in a bar graph, indicating the amounts of solids, liquid and gas flow rates (**Fig. 18**).

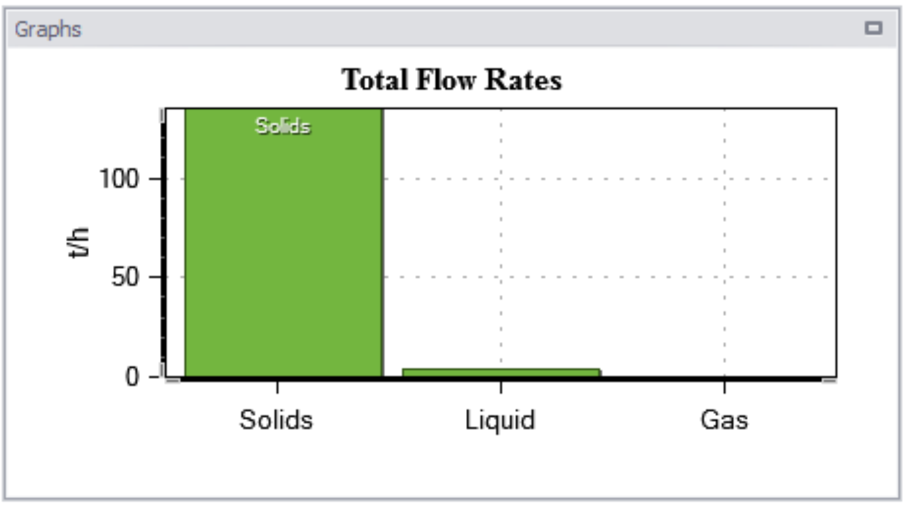


Fig. 18. Total flow rate graph.

45.3.1.2. Minerals

Minerals can be added by selecting them from the HSC Geo mineral database, or a new mineral can be created from scratch. In both cases the element composition as well as the specific gravity can be edited freely. The upper bar buttons for setting up the minerals are shown in **Fig. 19**.

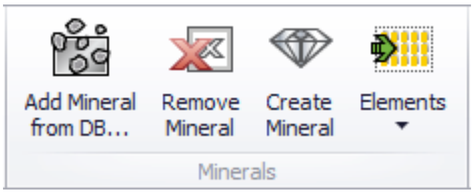


Fig. 19. Buttons for adding minerals from the database, removing minerals, creating new custom minerals, and editing their elemental composition.

- ✓ To open the HSC Geo **Select Minerals** tool, click Add Mineral from DB...
- ✓ You can search for the mineral from the database; once the selected list is ready, click OK to accept (**Fig. 20**).

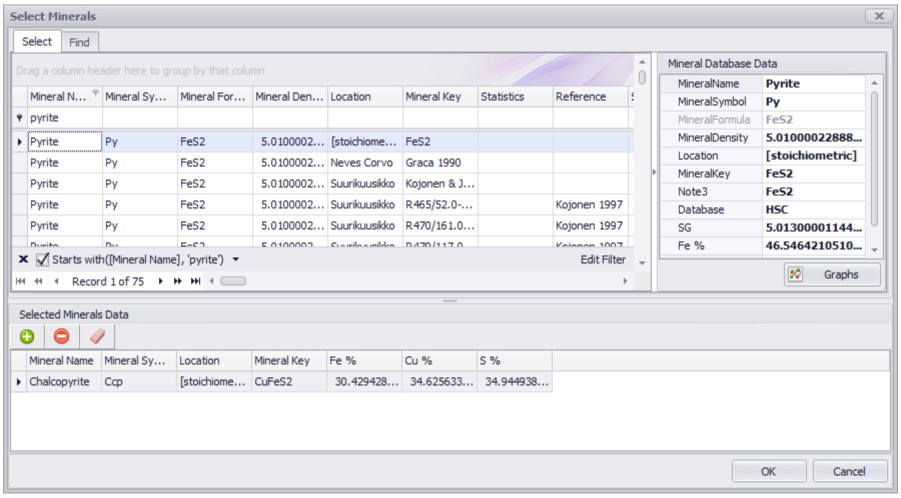


Fig. 20. Selecting minerals from the database.

Once the minerals are added, they will appear on the list, where the name, code, S.G., and formula can be edited (**Fig. 21**). The element composition of the minerals is presented in the lower part of the display, in the **Mineral Matrix** (**Fig. 22**).

Mineral	Code	S.G.	Formula	DB Ref.
Chalcopyrite	Ccp	4.35	CuFeS2	M/Ccp/40
Pyrite	Py	5.01	FeS2	M/Py/54
Quartz	Qtz	2.65	SiO2	M/Qtz/41

Fig. 21. List of selected minerals.

The Mineral Matrix allows you to edit the list of included elements; new elements can be added simply by typing them on the list and/or editing the existing elements. In the same way, the element wt% in each mineral can be edited.

Note I: the element wt% in each mineral is typically approximately 100%. However, this is not necessary; the chemical composition of a mineral can present just the measured elements for example.

Note II: the editing of the mineral properties (element wt%, S.G., etc.) does not affect them on the HSC Geo database. The edited minerals properties are only applied in the current HSC Sim simulation feed stream.

B2   34.6256332397461

	A	B	C	D
1	Element	Ccp	Py	Qtz
2	Cu	34.63		
3	Fe	30.43	46.55	
4	O			53.26
5	S	34.94	53.45	
6	Si			46.74
7	Zn			
8				
9				

Mineral Matrix

Fig. 22. Mineral matrix for presenting and editing the element compositions of selected minerals.

Alternatively, to edit the Mineral Matrix element list in the lower part of the dialog, elements can be added, removed, or selected from the periodic table on the Elements button menu, shown in **Fig. 23**.

A)

B)

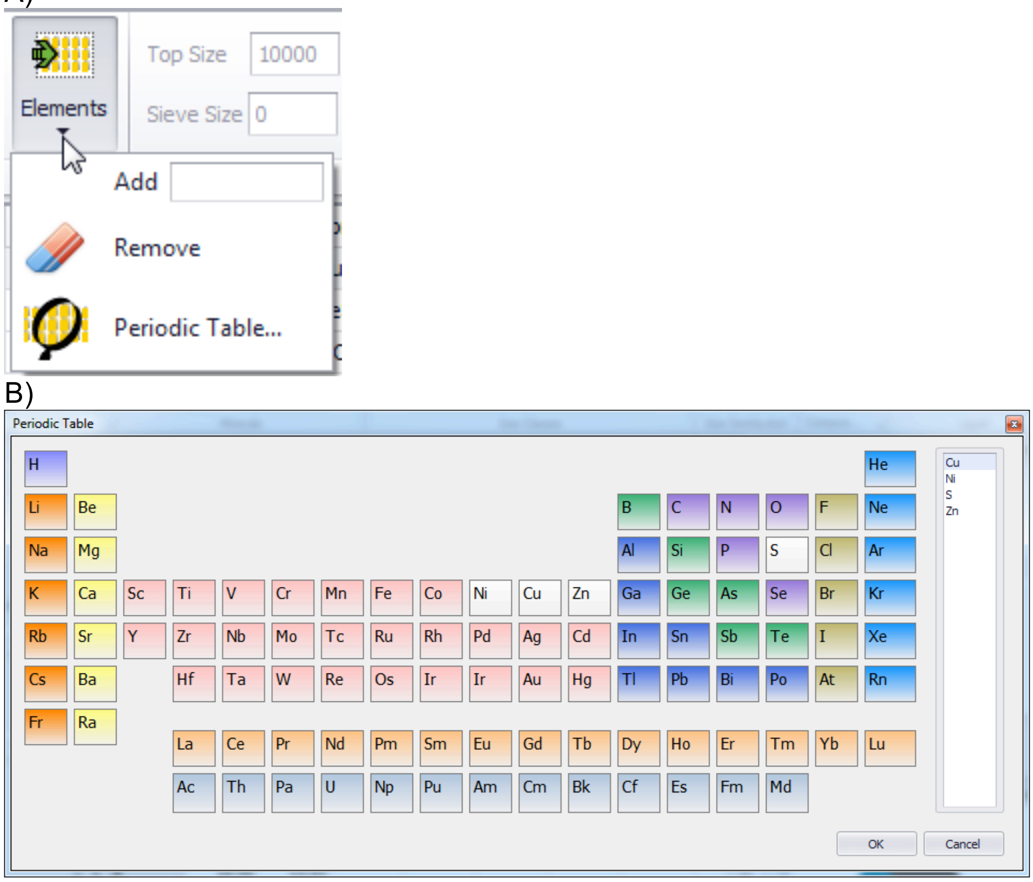


Fig. 23. Editing of elements, and selecting them from the periodic table.

The selected mineral (**Fig. 21**) properties are presented on the properties panel on the right (**Fig. 22**), and its element composition is presented visually in a pie chart (**Fig. 25**).

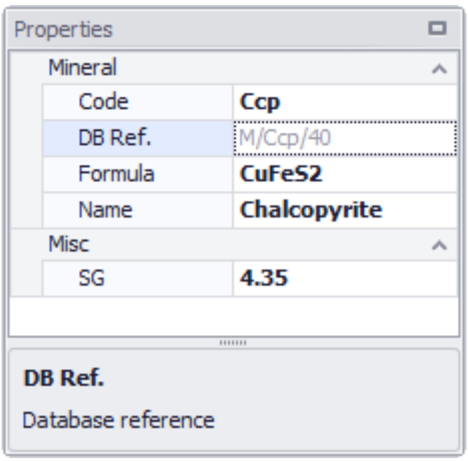


Fig. 24. Mineral properties.

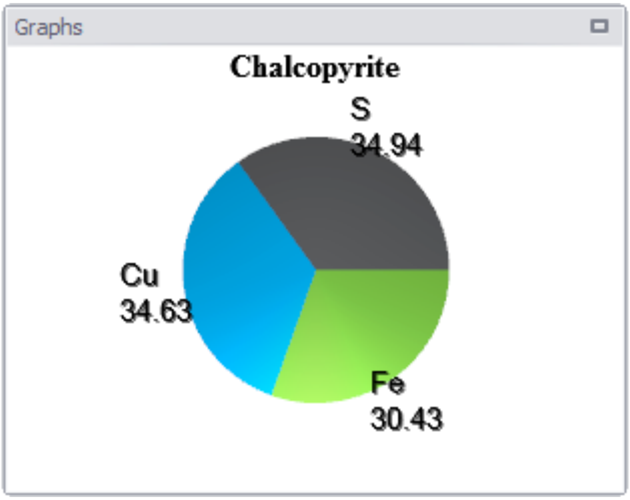


Fig. 25. Graphical presentation of the elemental composition of a mineral.

45.3.1.3. Size classes

The sieve size classes can be set up and edited as follows (**Fig. 26**):

- ✓ **Top Size** can be given or left empty; this affects the way the mean size of the topmost class is calculated
- ✓ **Sieve Size** is given and accepted by pressing Enter or the **Add Sieve** button (**Fig. 26**); alternatively there is a right mouse button tool for this (**Fig. 27**)
- ✓ The selected sieve can be removed by clicking **Remove Sieve**; or by right-clicking (**Fig. 27**)
- ✓ **Create Sieve Series** offers a way to create standard sieve series up to the given **Top Size** by using (**Fig. 28**):

- ISO 565 Test Sieves
- American Standard (ASTM E11)
- British Standard (BS 410)
- Square root of 2 series (down to > 1 µm)
- OR to create a given number of square root 2 series classes (up from 1 µm). In this case, Top Size is not needed.

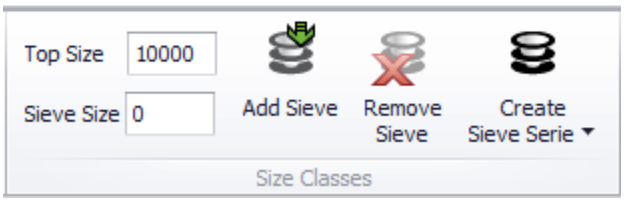
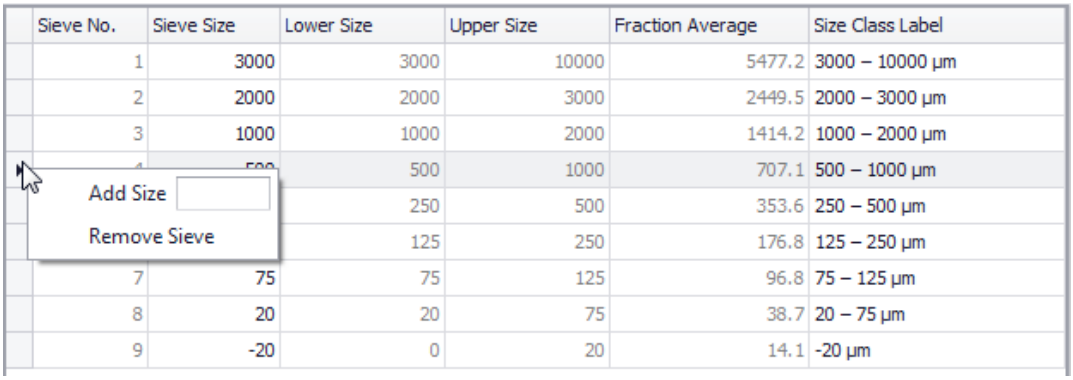


Fig. 26. Tool for creating and editing sieve size classes.



Sieve No.	Sieve Size	Lower Size	Upper Size	Fraction Average	Size Class Label
1	3000	3000	10000	5477.2	3000 – 10000 µm
2	2000	2000	3000	2449.5	2000 – 3000 µm
3	1000	1000	2000	1414.2	1000 – 2000 µm
[illegible]	[illegible]	500	1000	707.1	500 – 1000 µm
		250	500	353.6	250 – 500 µm
		125	250	176.8	125 – 250 µm
7	75	75	125	96.8	75 – 125 µm
8	20	20	75	38.7	20 – 75 µm
9	-20	0	20	14.1	-20 µm

Fig. 27. Size classes view for editing sieves and size class labels.

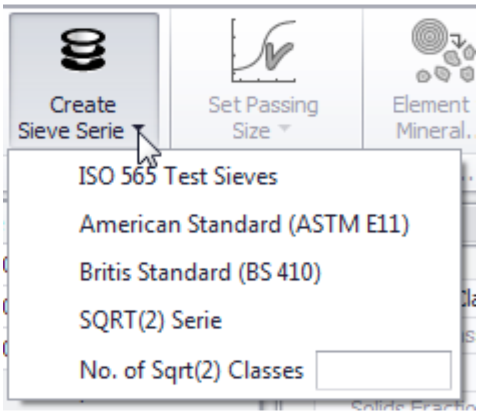


Fig. 28. Creating of a predefined sieve series.

Both the size class and size distribution properties are summarized on the right-hand panel (**Fig. 29**).

***The user-editable values in Properties are*:**

Size Classes:

- ✓ Select whether the size class labels are generated automatically or edited manually in the size class list (**Fig. 27**). These labels can be used in the unit models when you need to enter model parameters by size
- ✓ Measurement unit: µm or mm, this affects how the size data is shown in the Stream Setup tool, but for stream particles, the base unit for size is always the micrometer
- ✓ Top size, can be given or left empty

Size Distribution:

- ✓ Type: user-given size assay data or automatically generated distribution based on Rosin-Rammler or Gaudin-Schuhmann equations
- ✓ Rosin-Rammler equation parameters: a = 63.2 % passing size, b = distribution slope.
- ✓ Gaudin-Schuhmann equation parameters: k = 100% passing size, m = distribution slope.

***The calculated values and information presented in the Properties are* (Fig. 29):**

Size Classes:

- Number of size classes
- Indication if the feed is Unsized (bulk) or Sized
- Indication if the Top Size is given

Size Distribution:

- Calculated 50% passing size, P50
- Calculated 80% passing size, P80

Properties	
Classes	
Automatic Class Labels	**True**
No. Size Classes	9
Size Unit	**µm**
Solids Fractioning	Sized
Top Size	**10000**
Top Size Given	True
Distribution	
Distribution Type	**Assay Data**
Gaudin-Schuhmann k	**0.00**
Gaudin-Schuhmann m	**0.00**
P50	846.92
P80	2000.00
Rosin-Rammler a	**0.00**
Rosi-Rammler b	**0.00**
Size Unit	
Unit of the sieve sizing	

Fig. 29. The size class and size distribution properties.

45.3.1.4. Size distribution

The size distribution is given as wt% retained values for each size; the last size class is automatically calculated to total 100% (**Fig. 30**). Also, the cumulative passing % values are calculated automatically. Negative values are not allowed, and are indicated by red color, which must be corrected before proceeding further. If, instead of Assay Data (user-given values), the Rosin-Rammler or Gaudin-Schuhmann distribution calculation is selected (**Fig. 29**), the wt% values in **Fig. 30** will also be generated automatically.

Sieve No.	Sieve Size	Weight Retained (%)	Cumulative Passing (%)	Size Class Label
1	3000	8.9	91.1	3000 – 10000 µm
2	2000	11.1	80.0	2000 – 3000 µm
3	1000	24.7	55.3	1000 – 2000 µm
4	500	22.2	33.1	500 – 1000 µm
5	250	14.9	18.2	250 – 500 µm
6	125	8.7	9.6	125 – 250 µm
7	75	3.7	5.9	75 – 125 µm
8	20	4.3	1.6	20 – 75 µm
9	-20	1.6		-20 µm

Fig. 30. Defining the size distribution.

The size distribution (either Rosin-Rammler or Gaudin-Schuhmann) can be calculated in two ways:

1) By the equation, based on the two parameters given in Properties (**Fig. 29**)
2) By giving the known passing size value (e.g. for P80), the slope parameter is as given in Properties (**Fig. 29**), and the second parameter is solved by HSC Sim, by pressing Enter or clicking Calculate Distribution from the **Set Passing Size** button menu, shown in **Fig. 31**.

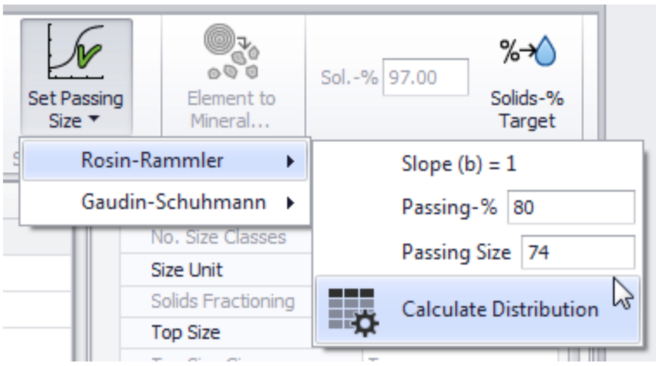


Fig. 31. Automatic calculation of the size distribution to match the given passing size value.

Finally, the cumulative size distribution curve can be seen graphically (**Fig. 32**). The figure includes both data points for each given sieve size and the quadratic spline interpolation curve between them.

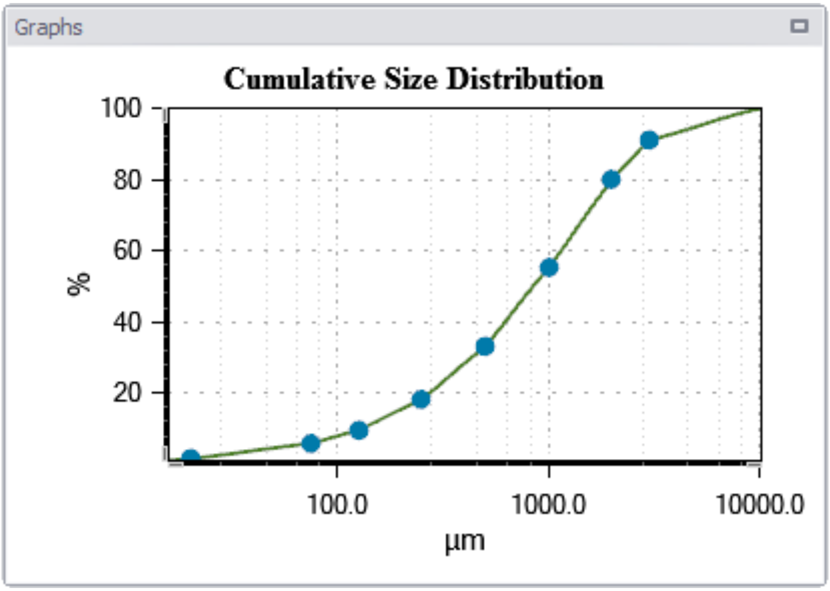


Fig. 32. Logarithmic presentation of the cumulative passing size; both the given sieve size data points and quadratic spline interpolation between them.

45.3.1.5. Mineral and elemental composition

The mineral compositions and resulting elemental compositions are edited from the tables shown in **Fig. 33**. The tables consist of:

Mineral Composition:

- Σ = 100: one of the minerals is always calculated as 100 % - the sum of all the other minerals
- Mineral: list of minerals (Codes)
- Bulk: bulk composition (cannot be edited when sized data; is then calculated automatically)
- Unit: %
- Size fractions: mineral composition of the fractions

Elemental Composition:

- Analyzed: indicates if the value is analyzed, thus it will not be updated based on the minerals. Instead, this is then the initial data for *element to mineral conversion*

- Element: list of all elements
- Bulk: bulk composition (cannot be edited when sized data, is then calculated automatically), editable for 'Analyzed' elements in the case of unsized data
- Unit: %
- Size fractions: elemental composition of the fractions. These are automatically calculated based on the minerals, except if the element is marked 'Analyzed' → will be the initial data for *element to mineral conversion*

F3 | 12.6263408131342

	A	B	C	D	E	F	G	H
1	Σ = 100	Mineral	Bulk	Unit	-20 µm	20 – 75 µm	75 – 125 µm	125 – 250 µm
2	☐	Ccp	2.277274	%	1.0686	2.8302731	3.78332431	1.992743339
3	☐	Py	26.11407	%	21.564	25.276068	43.547916	21.89495501
4	☑	Qtz	71.60866	%	77.368	71.893659	52.6687597	76.11230165
5								
6								

Mineral Composition

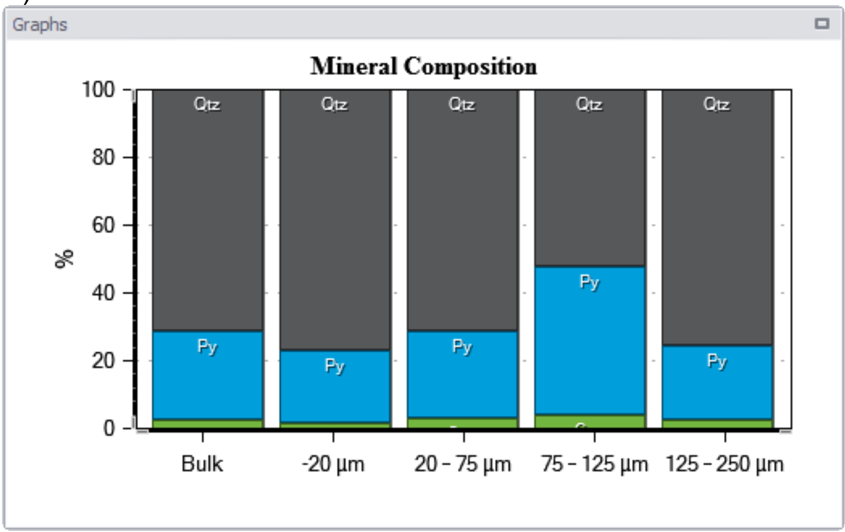
	A	B	C	D	E	F	G	H
1	Analyzed	Element	Bulk	Unit	-20 µm	20 – 75 µm	75 – 125 µm	125 – 250 µm
2	☑	Cu	0.78852	%	0.37	0.98	1.31	0.69
3	☐	Fe	12.84813	%	10.362	12.626341	21.4212403	10.79769835
4	☐	O	38.13627	%	41.203	38.288052	28.0495422	40.53475392
5	☑	S	14.7547	%	11.9	14.5	24.6	12.4
6	☐	Si	33.47239	%	36.164	33.605607	24.6192176	35.57754773
7								
8								

Elemental Composition

Fig. 33. Mineral and elemental composition tables.

When the tables (shown in **Fig. 33**) are clicked, a graph will show either the mineral or elemental composition by size, see **Fig. 34**.

A)



B)

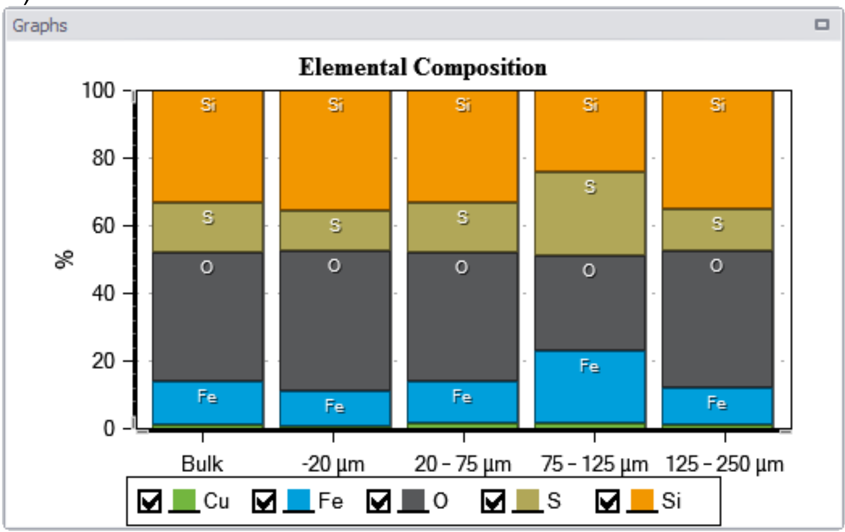


Fig. 34. Bar graphs of A) mineral and B) elemental stream composition for bulk and each size class.

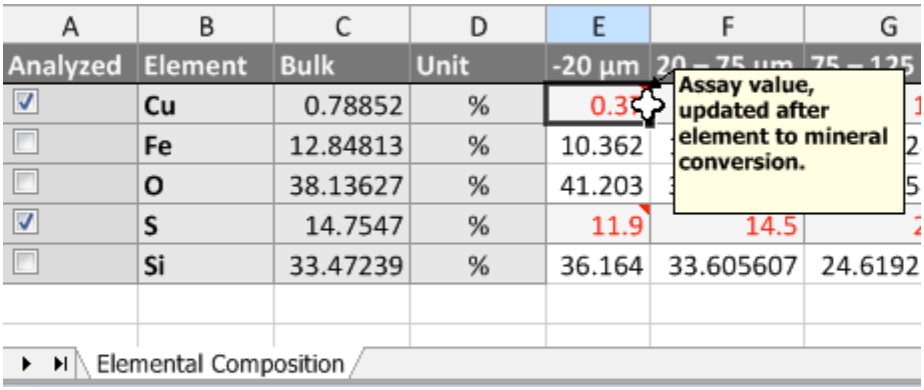
A) <u>Setting mineral composition – elements are calculated</u>

The mineral composition can be simply entered in the upper table by each size class. One of the minerals is always selected, with **Σ = 100**, to be calculated as 100% minus all the other minerals (**Fig. 35**). The elements are automatically calculated and updated, but only if they are not marked **Analyzed**. The analyzed elements are the initial values for *element to mineral conversion* – explained in B).

1.06857251515991

A	B	C	D	E	
Σ = 100	Mineral	Bulk	Unit	-20 µm	20 -
☐	Ccp	2.277274	%	1.0686	2.8
☐	Py	26.11407	%	21.564	25
☑	Qtz	71.60866	%	77.368	71

Fig. 35. Entering the mineral wt% and selecting the Σ = 100 mineral.



A	B	C	D	E	F	G
Analyzed	Element	Bulk	Unit	-20 µm	20 – 75 µm	75 – 125
☑	Cu	0.78852	%	0.3		1
☐	Fe	12.84813	%	10.362		2
☐	O	38.13627	%	41.203		5
☑	S	14.7547	%	11.9	14.5	2
☐	Si	33.47239	%	36.164	33.605607	24.6192

Fig. 36. Analyzed elements, not calculated from minerals, but updated after element to mineral conversion.

B) Setting element composition – minerals are calculated

Firstly, select the analyzed elements (**Fig. 36**); these are the initial values for element to mineral conversion. The conversion is done using HSC Geo in its **Modal Calculations** tool. To open HSC Geo for modal calculation, click the '**Element to Mineral...**' button. The Modal Calculations dialog shown in **Fig. 37** will open.

The Modal Calculations tool indicates the selected elements in the periodic table and lists the minerals included in the Stream Setup. The calculation procedure is described in Chapter 84; in brief the steps are:

- ✓ Select the mineral(s) for calculation round 1
- ✓ Select the elements(s) for calculation round 1
- ✓ Add new calculation round(s) using the (+) 'Add Round' button
- ✓ The last round is practically always marked 'Sum = 100 %', thus that mineral is to be the remaining gangue material
- ✓ All the calculation rounds are then performed sequentially, with the selected method when you click 'Calculate'
- ✓ When mineral composition calculation results are satisfactory, they are brought to Stream Setup by clicking 'Update and Close'

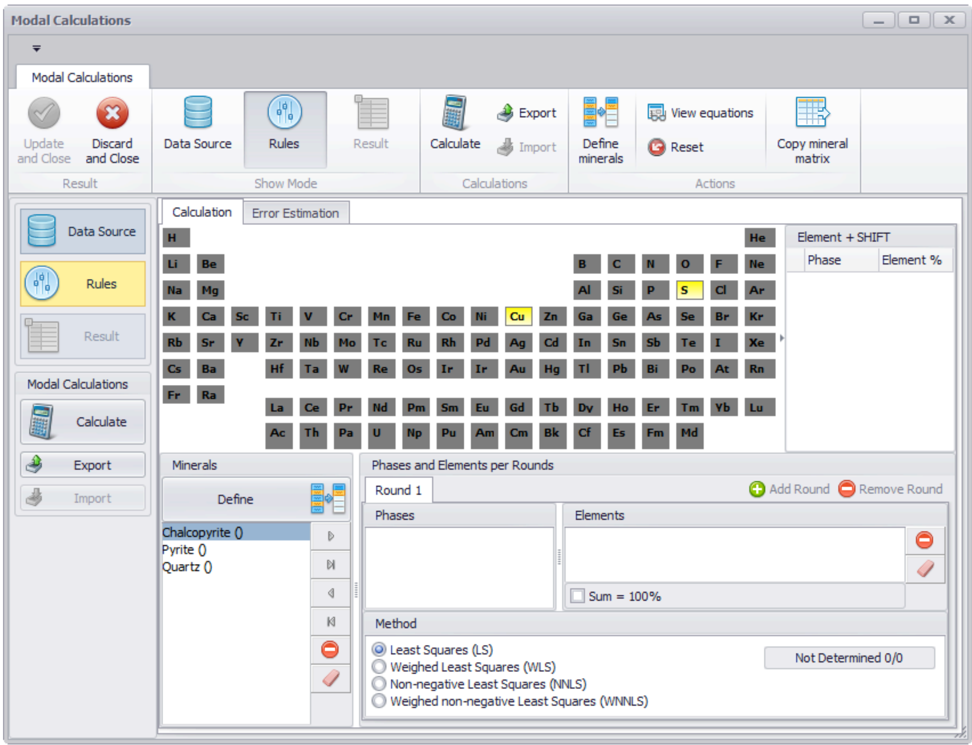
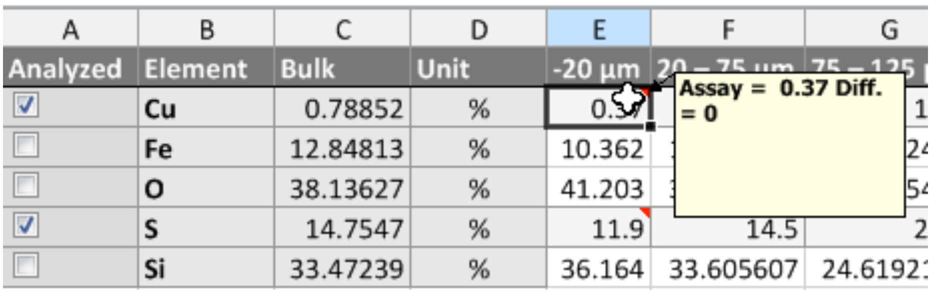


Fig. 37. HSC Geo Modal Calculations

When the element to mineral calculation with HSC Geo is ready, the results are seen in the Stream Setup Composition view, **Fig. 38**. Now, the tooltip of the 'Analyzed' values shows the original assay value, and the difference from it. The value in the corresponding cell shows the element wt% obtained in the mineral to element back calculation with the HSC Geo Modal Calculation tool.



A	B	C	D	E	F	G
Analyzed	Element	Bulk	Unit	-20 µm	20 – 75 µm	75 – 125
☑	Cu	0.78852	%	0.3		1
☐	Fe	12.84813	%	10.362		24
☐	O	38.13627	%	41.203		54
☑	S	14.7547	%	11.9	14.5	2
☐	Si	33.47239	%	36.164	33.605607	24.6192

Fig. 38. Elements back-calculated from the minerals, after modal calculation in HSC Geo.

45.3.2. Liquid feed

The total liquid flow rate and its unit can be set in the Total Liquid Flow Rate view, see **Fig. 40**. Also, the liquid flow rate can be automatically calculated and kept updated, based on the given solids flow rate and solids percentage (**Fig. 39**), when the '**Solids % Target**' button is held down. Otherwise the 'Sol. %' text field indicates the calculated solids percentage based on the given solids and liquid flow rates.

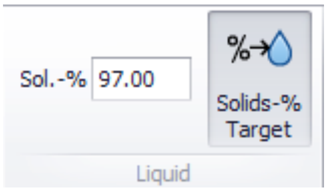


Fig. 39. Solids % target value for calculating the required liquid t/h

Phase Total	Amount	Unit
Liquid flow rate	4.18	t/h

Fig. 40. Total liquid flow rate.

45.3.3. Gas feed

The total gas phase flow rate is set from the Amount field shown in **Fig. 41**.

Phase Total	Amount	Unit
Gas flow rate	3.8	t/h

Fig. 41. Total gas total flow rate.

45.4. Selecting unit models

The unit models are selected for the unit icons of the flowsheet by using the Select Unit Models tool **Fig. 43**, which can be opened by:

- ✓ HSC Sim menu bar: Tools → Select Unit Models
- ✓ Right-clicking the unit (**Fig. 42**)
- ✓ Double-clicking the unit

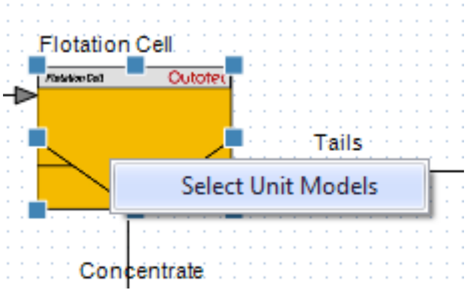


Fig. 42. Selecting a unit model for a unit.

The unit models are selected from the model library simply by double-clicking the model which is then assigned to the selected unit(s), **Fig. 43**. All the HSC Sim minerals processing unit models are shown under the Particles tab on the model list. The Select Unit Models dialog is also described in Chapter 40 (section 40.2.2.).

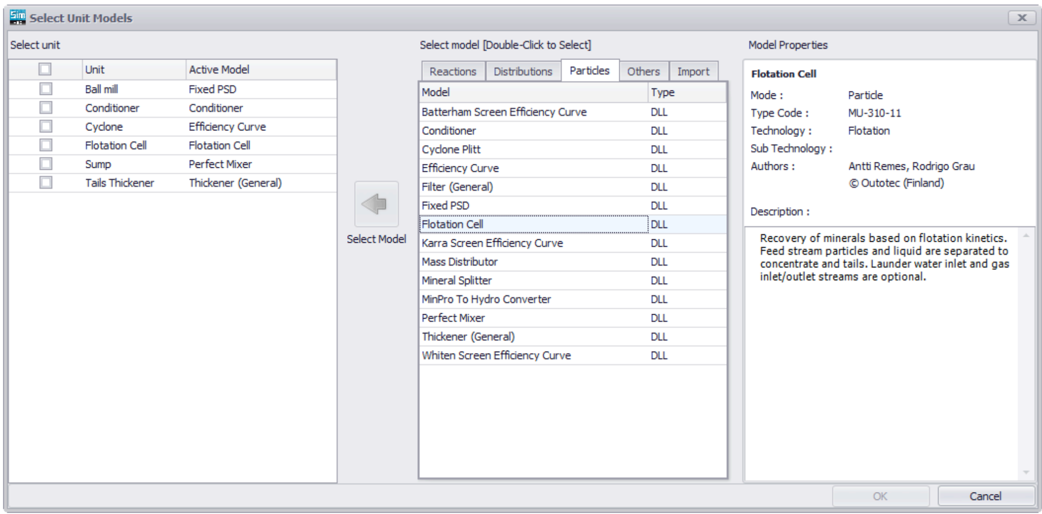


Fig. 43. Select Unit Models.

Once the models have been applied to the units, the model parameters are next edited and viewed with the model editor as shown in **Fig. 44**. The model input and output streams can be viewed, their connection to the model inputs and outputs can be configured, and controls for the models can be defined.

Setting up the **Controls** and **Cell References** between the units is described in sections 43.5. and 44.2.5.

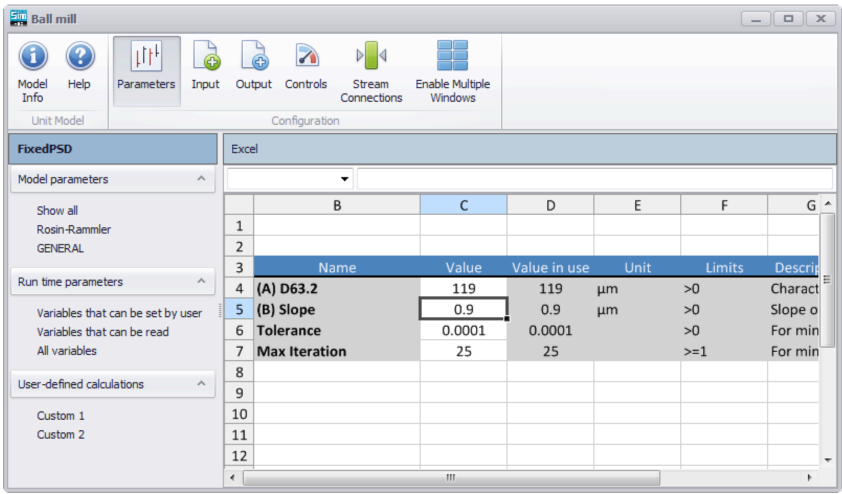


Fig. 44. Dialog to enter and view the unit model parameters, stream content, stream connections, and model controls.

45.5. Run simulation and view the results

45.5.1. Simulate

To run the simulation from the HSC Sim upper bar buttons (**Fig. 45**):

- ✓ Set the number of calculation rounds. This is how many sequential calculations are repeated through all the units.
- ✓ Click the ‘Simulate’ button
- ✓ If the flowsheet is not yet in balance (stream content is still changing round by round), repeat the simulation; you may also increase the number of calculation rounds

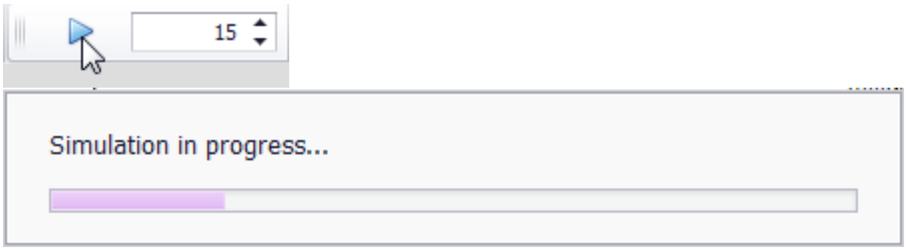
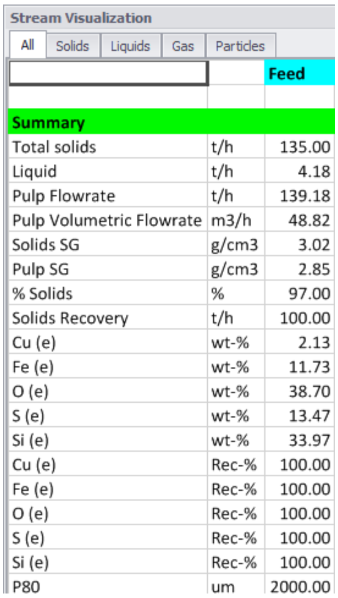


Fig. 45. Simulating the process.

45.5.2. Visualization, tables, graphs, scenarios

In the Visualization mode  the stream content and listing of all the variables calculated from the particles can be seen with the Stream Viewer (**Fig. 46**). A mineral processing stream consists of the following variables:

- Total solids, t/h
- Liquid, t/h
- Pulp flow rate, t/h
- Pulp volumetric flow rate, m^3/h
- Solids SG, g/cm^3
- Pulp SG, g/cm^3
- % Solids
- Solids recovery %
- Element wt%
- Elements recovery %
- Mineral wt%
- Mineral recovery %
- Passing sizes, P50 and P80 µm
- Size fraction percentages %



Stream Visualization

All | Solids | Liquids | Gas | Particles

		Feed
Summary		
Total solids	t/h	135.00
Liquid	t/h	4.18
Pulp Flowrate	t/h	139.18
Pulp Volumetric Flowrate	m3/h	48.82
Solids SG	g/cm3	3.02
Pulp SG	g/cm3	2.85
% Solids	%	97.00
Solids Recovery	t/h	100.00
Cu (e)	wt-%	2.13
Fe (e)	wt-%	11.73
O (e)	wt-%	38.70
S (e)	wt-%	13.47
Si (e)	wt-%	33.97
Cu (e)	Rec-%	100.00
Fe (e)	Rec-%	100.00
O (e)	Rec-%	100.00
S (e)	Rec-%	100.00
Si (e)	Rec-%	100.00
P80	um	2000.00

Fig. 46. Stream Viewer for inspecting the stream content

Values that are shown on the flowsheet stream value labels are selected from the HSC Sim main window dropdown menu, see **Fig. 47**. The same values are also used for the Sankey diagram, presenting the value with the flowsheet stream line width.

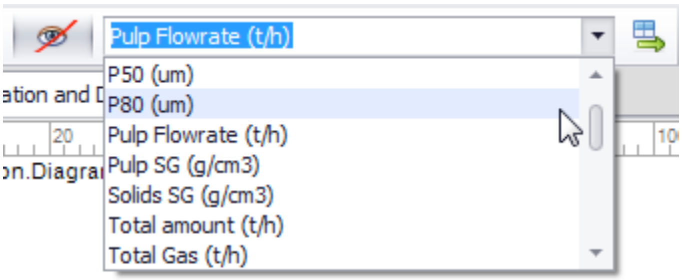


Fig. 47. Stream Visualization to set the values to be shown on the stream value labels and stream Sankey diagram (line width).

In addition, the variables can be shown on the flowsheet in tables. The variables can be inserted and edited with the Stream Table Editor (**Fig. 48**); see section 40.1.4. Tables can also be inserted from Tables button on the left (**Fig. 49**) and by editing the content manually with cell reference and text.

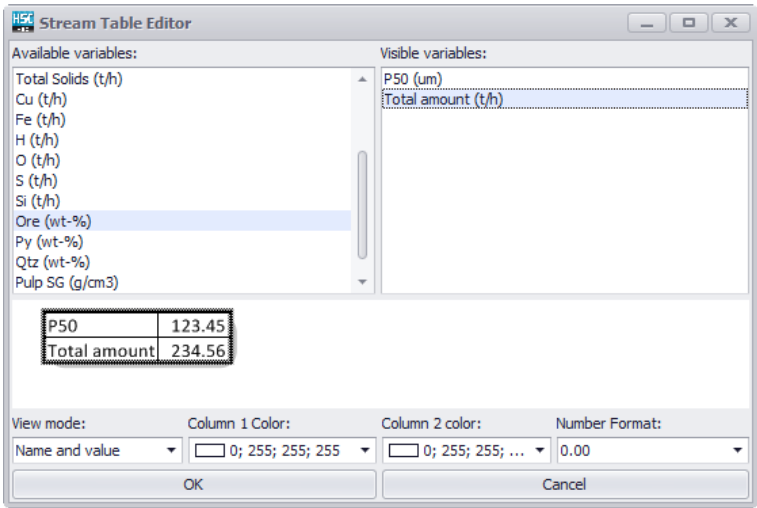


Fig. 48. Stream Table Editor for adding tables that present the stream variable details.

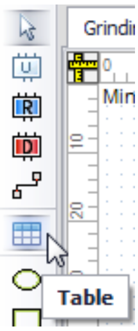


Fig. 49. Inserting tables from the left-bar button Table selection.

It is also possible to repeat a sequence of simulations with different model parameterization and/or feed composition, and record the simulation results (**Fig. 50**). This can be done by selecting:

✓ HSC Sim menu bar: Tools → Run Scenarios

This will open the Scenario Editor described in section 40.2.3.

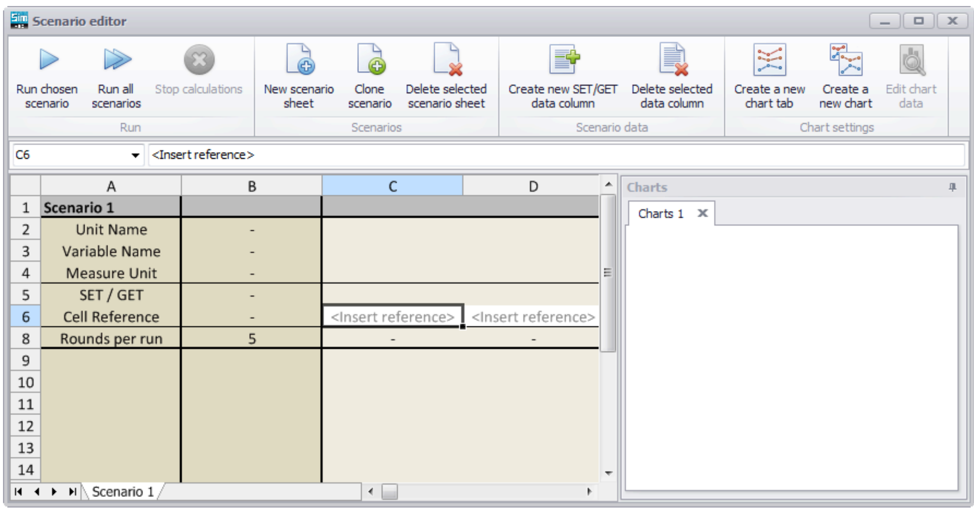


Fig. 50. Scenario Editor, for running different simulation set-ups and recording the simulated values.

45.6. Opening an HSC 7 flowsheet in HSC 8

The old HSC 7 flowsheet can be opened, simulated and edited, albeit with some restrictions, in HSC 8. The steps for handling HSC 7 flowsheet models are described briefly in the following section.

45.6.1. Conversion from HSC 7 to HSC 8 format

When a HSC Sim 7 flowsheet model (.fls file) is opened, HSC Sim 8 will convert it into the new format (**Fig. 51**). For a large flowsheet, this may take several minutes. For more details about importing, see Chapter 40 (section 40.4.).

Fig. 51. Importing an HSC 7 flowsheet.

When the importing is ready, save the model in a new separate folder.

45.6.2. Simulating the flowsheet

The HSC 7 imported models are simulated in a similar way, by setting the number of calculation rounds and clicking 'Simulate' (**Fig. 45**). If some errors or warning occur, please refer to Chapter 40 (section 40.4) for how to solve them.

45.6.3. Modifying feed composition

The feed composition can be edited by selecting from the HSC Sim menu bar: Tools → Old Mineral Setup (visible only for imported models)

In Mineral Setup (**Fig. 52**) you can:

- ✓ Change the element wt% in each mineral
- ✓ Change the mineral SG
- ✓ Change the water SG
- ✓ Change the feed rate t/h
- ✓ Change the particle size distribution wt%
- ✓ Change the mineral composition by size
- ✓ Change the fraction amounts of floatability classes

But you cannot:

- Add, remove or rename minerals
- Add or remove elements
- Change the number of size classes
- Change the number of floatability classes

since they affect the variable list content, which can be edited only in HSC 7 for the old file format models.

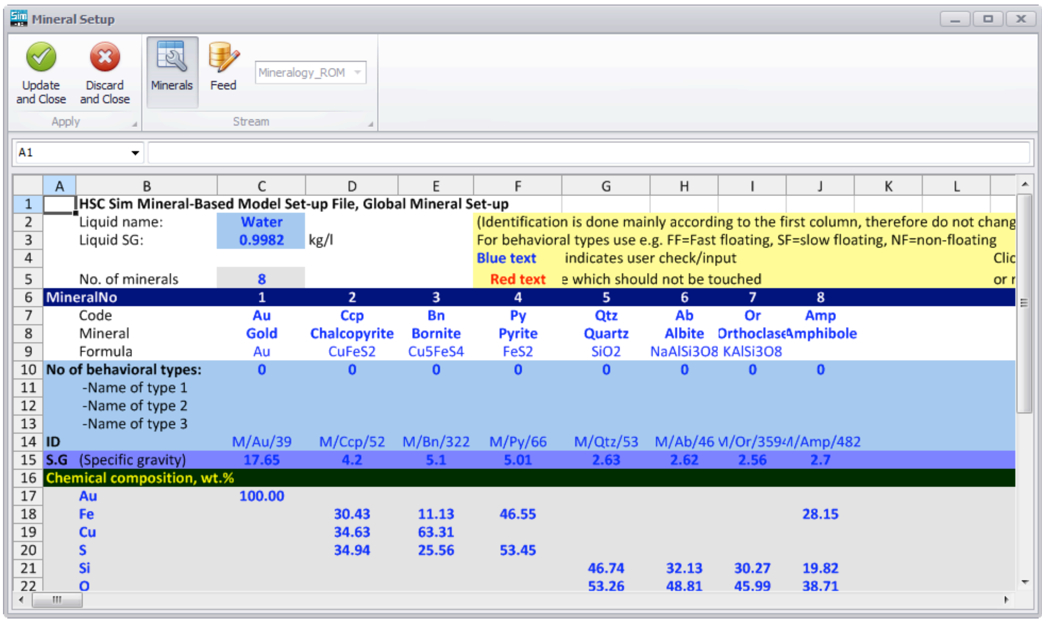


Fig. 52. Mineral Setup for HSC 7 imported models

45.6.4. Editing model parameters and reloading the unit models

Open the unit model editor by double-clicking the unit. It opens a similar view as in HSC 7 (**Fig. 53**), consisting of:

- Input: list of input streams of the units
- Output: list of output streams of the unit
- Dist: material distribution calculation form
- Control: model controls sheet
- Model: model parameters sheet
- Wizard: sheet containing the Excel Wizard initial data
- Other sheet: sheets that the model may contain, e.g. Tank

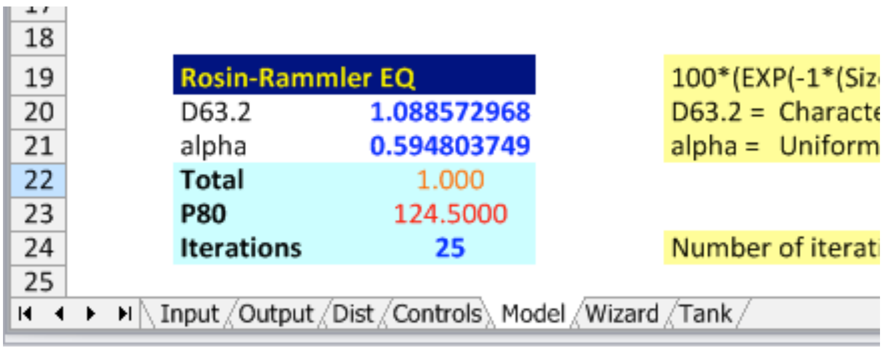


Fig. 53. Example of unit editor navigation tabs for HSC 7 imported models.