85. Geo – Processing Mineral Liberation Data

85.1. Introduction

The Mineral Liberation Analyzer, MLA, is an automated mineral analysis system that can be used in analyzing mineral abundances, particle sizes, grain sizes and liberation characteristics (Fandrich, Gu, Burrows, & Moeller, 2007; Gu, 2003)[1,2]. HSC Geo includes tools for the processing of Mineral Liberation analysis:

- For opening the MLA (Mineral Liberation Analysis of FEI) files to study modal composition, elemental composition, mineral mode of occurrence, etc.
- For processing MLA files for reporting (e.g. adjusting modal composition of MLA to match with chemical assays)
- For preparing MLA data to be used in the Process Simulator HSC Sim

Particles are generated in HSC Geo through mineralogical information. There are two levels of information required:

- Global mineral setup (data)
- Feed stream – specific setup (data).

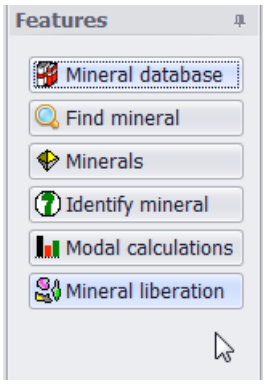
The global mineralogical information and mineral setup do not change from one stream to another. It consists of:

- A list of minerals and their properties including:
  - Name
  - Chemical formula
  - Specific gravity
  - Chemical composition
  - Number of behavioral types and their names (e.g. n=2, fast floating, slow floating)
- Size class information including
  - Measuring unit (mm / mm)
  - Number of size classes
  - Lower and upper boundary of each class and average
  - Name of the size class

Each input stream defines the mineralogical composition of the stream by size and possibly by behavioral types. An input stream data consists of:

- Mineral data (calculated from particle data)
  - Total solids flow rate of the stream (t/h)
  - Weight percentage of each size class (sums up to 100%)
  - Weight percentage of each mineral in each size class (sums up to 100%) and in bulk
  - Chemical composition of size fractions and bulk
- Particle data
  - List of particles in the stream
  - For each particle its flow rate, size and composition

For process liberation data, press “Mineral liberation” in the left panel:



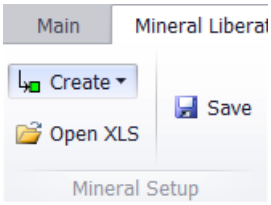
85.2. Reading MLA data

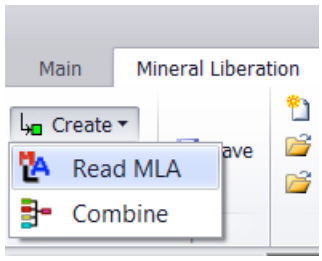
Reading of MLA data into HSC Geo consists of two stages:

1. Create the Mineral Setup
2. Create a Stream

85.2.1. Creating mineral setup

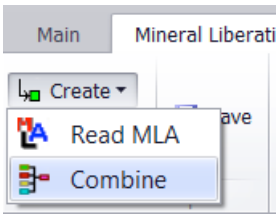
Press Create in the Mineral Setup Ribbon group and select Read MLA.



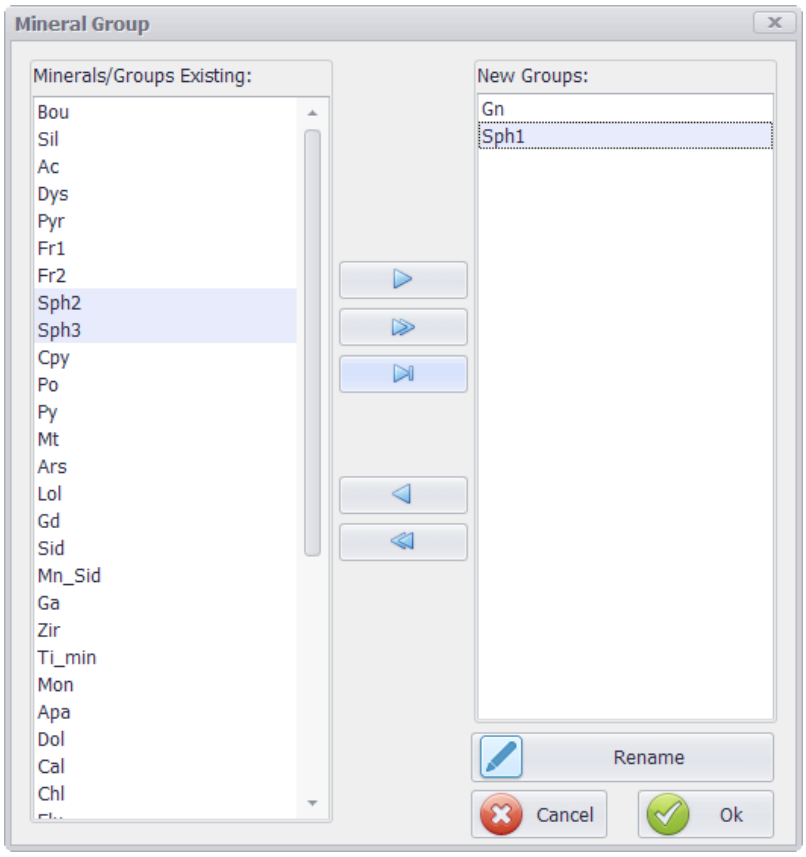


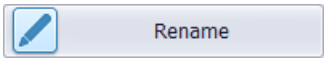
Open the appropriate MLA file and the measured minerals are listed.

Quite often a mineral list needs to be simplified, i.e. some phases are combined together. In this case, select Create – Combine:

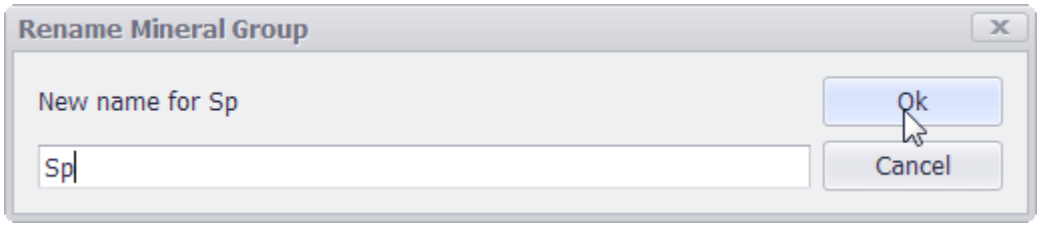


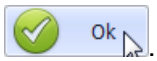
In the Mineral Group window, move the minerals from the left-hand side to the right-hand side by using arrow buttons:  to move one (selected) mineral and  to move all. Use  to move a mineral or several minerals to a selected group on the right-hand side.



Press 

to change the name of a mineral (group). Write a new name and press OK.



When ready, press 

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In the Size tab:

Edit the number of size fractions and their lower and upper sizes.

HSC Sim Mineral Based Model Size Set-up *Versi*

Size classes

Unit	**um**
Total:	**7**

No	Lower	Upper	Average Size	Label
1	0	10	4.47	0-10 um
2	10	20	14.14	10-20 um
3	20	38	27.57	20-38 um
4	38	75	53.39	38-75 um
5	75	106	89.16	75-106 um
6	106	150	126.10	106-150 um
7	150	300	212.13	150-300 um

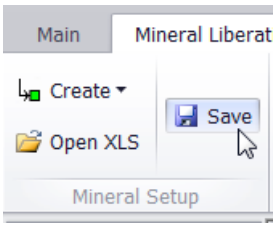
In this sheet you can change some values:

- Unit – give the measuring unit, e.g. mm, um
- Total – number of size classes, 0 = no size information used

Also, you can add new size classes or change the existing ones. The following columns are used:

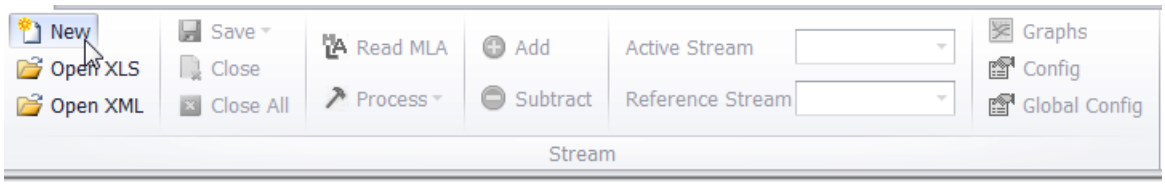
- No – incremental number of the size class
- Lower – lower limit of the size class
- Upper – upper limit of the size class
- Average size – average size of the class used in calculations (to add a class, copy the formula)
- Label – label used for the size class (to add a class, copy the formula)

When ready, press Save and give a name for the mineral setup. The normal practice is to name it MinSetup.xls and place it in the folder where the corresponding stream files will be stored.

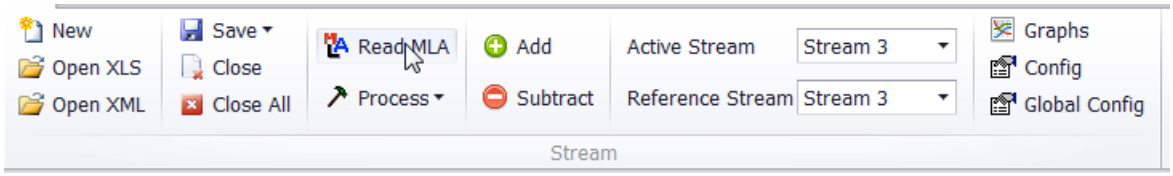


85.2.2. Creating a Stream File

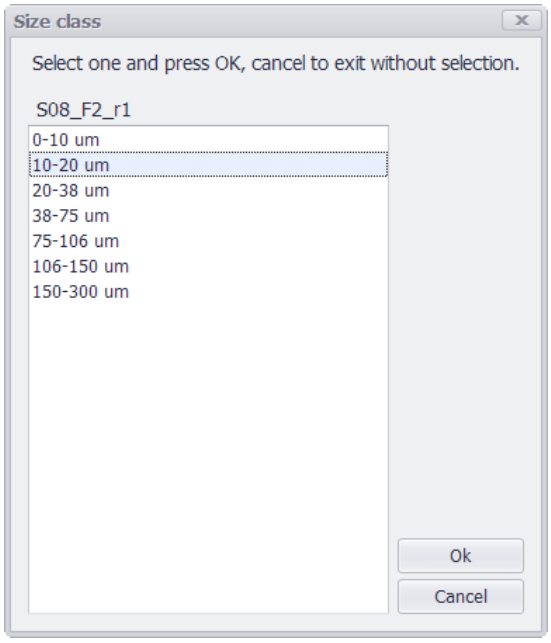
Press New in the Stream ribbon group.



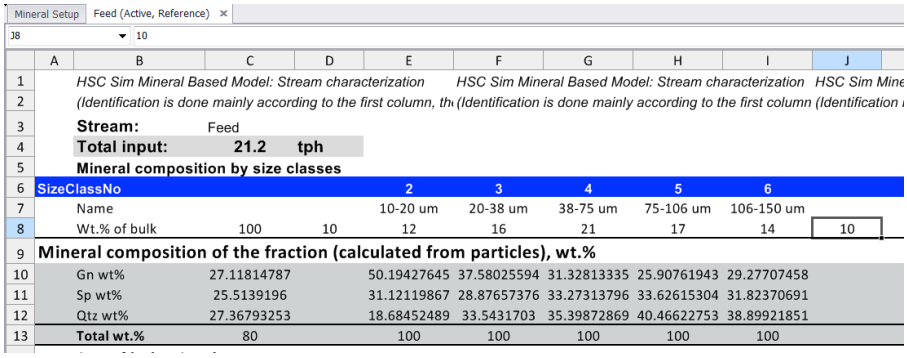
To load MLA measurement data, press Read MLA.



Generally, different MLA files (*.mdb) include only one size fraction. After selecting the file, select the appropriate size class.

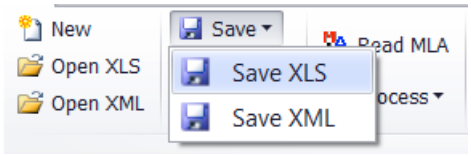


After reading all the measured size fractions, give a name to the stream (cell C3), give the total input (solids flow rate; C4) and give the size distribution, i.e. the distribution of mass between the size fraction (D8..J8…).



	A	B	C	D	E	F	G	H	I	J
1		*HSC Sim Mineral Based Model: Stream characterization*				*HSC Sim Mineral Based Model: Stream characterization*				*HSC Sim Mine*
2		*(Identification is done mainly according to the first column, th*				*(Identification is done mainly according to the first column (Identification*				
3		**Stream:**	Feed							
4		**Total input:**	**21.2**	**tph**						
5		**Mineral composition by size classes**								
6	**SizeClassNo**				**2**	**3**	**4**	**5**	**6**	
7		Name			10-20 um	20-38 um	38-75 um	75-106 um	106-150 um	
8		Wt.% of bulk	100	10	12	16	21	17	14	10
9	**Mineral composition of the fraction (calculated from particles), wt.%**									
10		Gn wt%	27.11814787		50.19427645	37.58025594	31.32813335	25.90761943	29.27707458	
11		Sp wt%	25.5139196		31.12119867	28.87657376	33.27313796	33.62615304	31.82370691	
12		Qtz wt%	27.36793253		18.68452489	33.5431703	35.39872869	40.46622753	38.89921851	
13		**Total wt.%**	80		100	100	100	100	100	

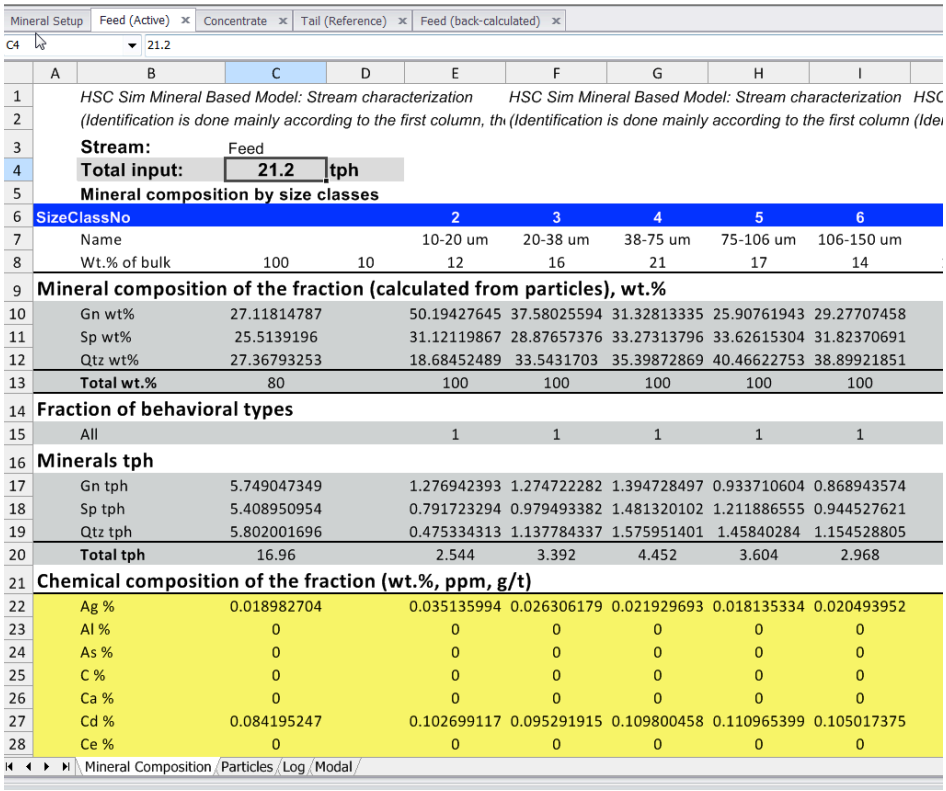
To save the stream, select Save – Save XLS (or Save XML; this also includes mineral setup information). Give a name to the stream and press Save.



85.2.3. Content and structure of a Stream file

A Stream file contains the following pages:

1. Mineral Composition
2. Particles
3. Log
4. Modal



	A	B	C	D	E	F	G	H	I
1		*HSC Sim Mineral Based Model: Stream characterization*				*HSC Sim Mineral Based Model: Stream characterization*			*HSC*
2		*(Identification is done mainly according to the first column, th*				*(Identification is done mainly according to the first column (Ide*			
3		**Stream:**	Feed						
4		**Total input:**	**21.2**	**tph**					
5		**Mineral composition by size classes**							
6	**SizeClassNo**				**2**	**3**	**4**	**5**	**6**
7		Name			10-20 um	20-38 um	38-75 um	75-106 um	106-150 um
8		Wt.% of bulk	100	10	12	16	21	17	14
9	**Mineral composition of the fraction (calculated from particles), wt.%**								
10		Gn wt%	27.11814787		50.19427645	37.58025594	31.32813335	25.90761943	29.27707458
11		Sp wt%	25.5139196		31.12119867	28.87657376	33.27313796	33.62615304	31.82370691
12		Qtz wt%	27.36793253		18.68452489	33.5431703	35.39872869	40.46622753	38.89921851
13		**Total wt.%**	80		100	100	100	100	100
14	**Fraction of behavioral types**								
15		All			1	1	1	1	1
16	**Minerals tph**								
17		Gn tph	5.749047349		1.276942393	1.274722282	1.394728497	0.933710604	0.868943574
18		Sp tph	5.408950954		0.791723294	0.979493382	1.481320102	1.211886555	0.944527621
19		Qtz tph	5.802001696		0.475334313	1.137784337	1.575951401	1.45840284	1.154528805
20		**Total tph**	16.96		2.544	3.392	4.452	3.604	2.968
21	**Chemical composition of the fraction (wt.%, ppm, g/t)**								
22		Ag %	0.018982704		0.035135994	0.026306179	0.021929693	0.018135334	0.020493952
23		Al %	0		0	0	0	0	0
24		As %	0		0	0	0	0	0
25		C %	0		0	0	0	0	0
26		Ca %	0		0	0	0	0	0
27		Cd %	0.084195247		0.102699117	0.095291915	0.109800458	0.110965399	0.105017375
28		Ce %	0		0	0	0	0	0

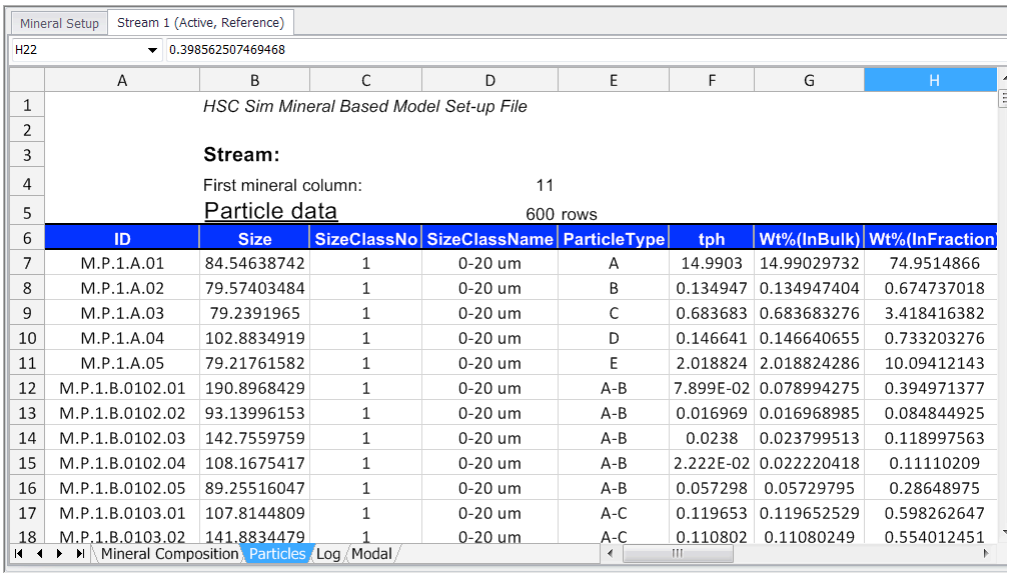
The mineral composition page contains:

- Total input (total solids flow rate, tph = tonnes per hour; cell D3)
- Mineral composition by size classes
- Fraction types
- Mineral flow rates (tph = tonnes per hour)
- Chemical composition of the fractions and the bulk

You can change the total input (D3) and the mass proportion of size classes (D8…I8…). The mineral composition, mineral tph and chemical composition are back-calculated from the particle information.

The Particles sheet contains the following information on each particle (or particle class):

- ID (more details below)
- Size = size of a particle
- Size class number = number of the size fraction
- Particle Type = particle type
- Tph = flow rate in tonnes per hour
- Wt%(In bulk) = weight percentage in the bulk
- Wt%(InFraction) = weight % of particle in a fraction
- NOP = number of particles in a particle class
- SG = specific gravity, i.e. density, kg/l
- Mineral composition by wt.% = mineral composition of a particle given in weight percentages
- Mineral composition by vol.% = same as above but as volume %
- Mineral composition by sur.% = same as above but as exposed surface area %



Mineral Setup | Stream 1 (Active, Reference)

H22 0.398562507469468

	A	B	C	D	E	F	G	H
1		*HSC Sim Mineral Based Model Set-up File*						
2								
3		**Stream:**						
4		First mineral column:		11				
5		Particle data		600 rows				
6		**ID**	**Size**	**SizeClassNo**	**SizeClassName**	**ParticleType**	**tph**	**Wt%(InBulk)**	**Wt%(InFraction**
7		M.P.1.A.01	84.54638742	1	0-20 um	A	14.9903	14.99029732	74.9514866
8		M.P.1.A.02	79.57403484	1	0-20 um	B	0.134947	0.134947404	0.674737018
9		M.P.1.A.03	79.2391965	1	0-20 um	C	0.683683	0.683683276	3.418416382
10		M.P.1.A.04	102.8834919	1	0-20 um	D	0.146641	0.146640655	0.733203276
11		M.P.1.A.05	79.21761582	1	0-20 um	E	2.018824	2.018824286	10.09412143
12		M.P.1.B.0102.01	190.8968429	1	0-20 um	A-B	7.899E-02	0.078994275	0.394971377
13		M.P.1.B.0102.02	93.13996153	1	0-20 um	A-B	0.016969	0.016968985	0.084844925
14		M.P.1.B.0102.03	142.7559759	1	0-20 um	A-B	0.0238	0.023799513	0.118997563
15		M.P.1.B.0102.04	108.1675417	1	0-20 um	A-B	2.222E-02	0.022220418	0.11110209
16		M.P.1.B.0102.05	89.25516047	1	0-20 um	A-B	0.057298	0.05729795	0.28648975
17		M.P.1.B.0103.01	107.8144809	1	0-20 um	A-C	0.119653	0.119652529	0.598262647
18		M.P.1.B.0103.02	141.8834479	1	0-20 um	A-C	0.110802	0.11080249	0.554012451

Mineral Composition | Particles | Log | Modal

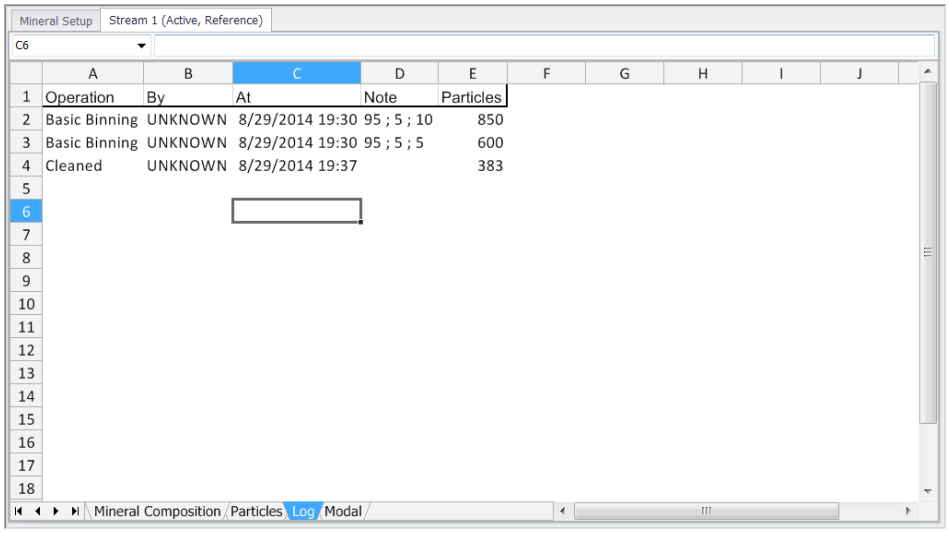
For all particles types the ID starts with "M.P" indicating mineral stream and particle. This is followed by a dot and the number of the size class.

The description of the particle type comes next:

- X - common type, assigned to particles after loading from an mdb file, "." is followed by the particle number in the Size Class (starting from 1)
- A (liberated) - type acquired from Basic Binning. "." is followed by the index of the main mineral (minerals are indexed starting from 1, and take exactly two digits)
- B (binary) - type acquired from Basic Binning. "." is followed by 2 indices of the main minerals (each index is two-digit). Then "." is followed by binary class indices or binary class index interval (after Pack)
- C (ternary) - type acquired from Basic Binning. "." is followed by 3 indices of the main minerals (each index is two-digit). Then "." is followed by the permutation index or interval of permutation indices (after Pack), determined by the proportions of the main minerals
- D (complex) - type acquired from Basic Binning. "." is followed by the index of the main mineral
- E - type acquired from Pack. "." is followed by the interval setting of the number of packed particles (interval starts from 01)

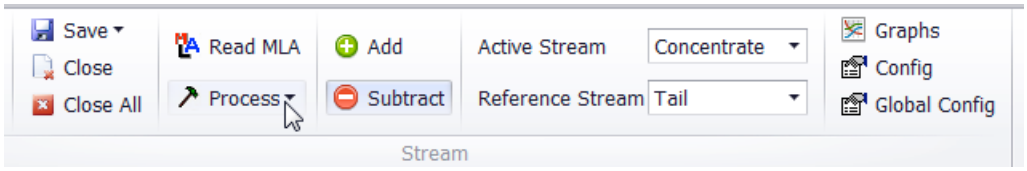
The Log page gives information about user actions:

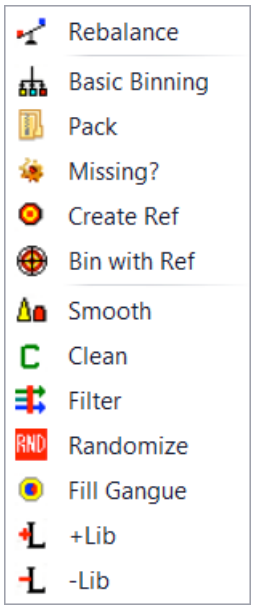
- Operation – name of the performed operation
- At – date of the operation
- Note – information about the operation
- Particles – number of particles after the operation



85.3. Processing liberation data

HSC Geo provides a number of processing routines under the Process button:





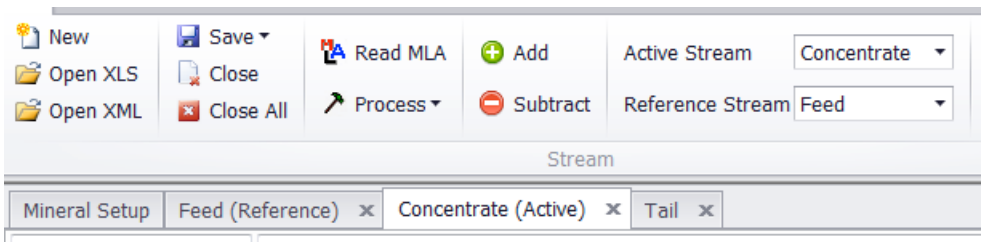
85.3.1. Active stream and basic operations

A stream may be in one of four states:

1. Active stream (indicated with text (Active) in the tab)
2. Reference stream (Reference)
3. Active and reference stream (Active, Reference)
4. Passive stream (not marked)

All the action takes place in the Active Stream. Reference Stream is used in some actions.

To select Active and Reference streams right-click on the tab or Active Stream and Reference Stream combo boxes.



You can close a tab in four different ways:

1. To close an active stream, press Close.
2. To close all streams, press Close All.

3. To close a selected tab, right-click and press Close in the popup menu.
4. To close a selected tab, press ‘x’ in the tab header.

To rename a stream, right-click on the appropriate tab and press Rename in the popup menu. You can also rename a stream on the Mineral Composition sheet.

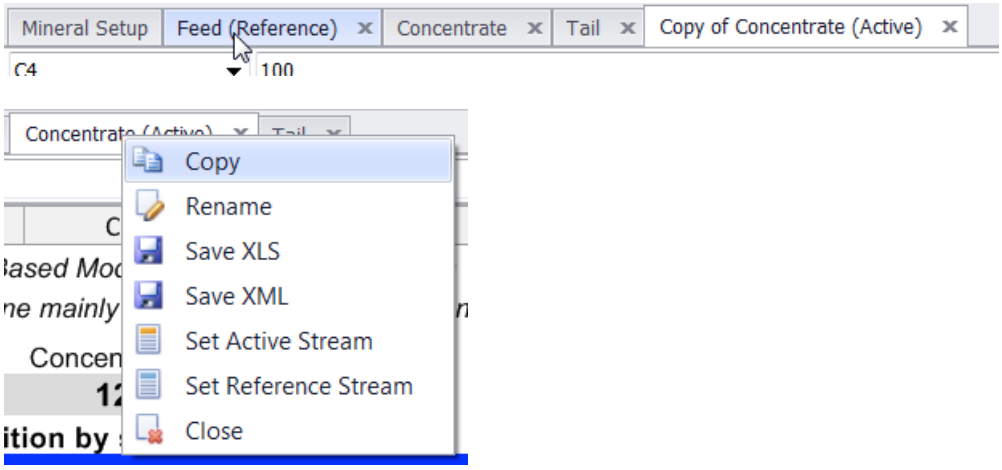
To copy a stream, right-click on the selected tab and press Copy in the popup menu.

A stream can be saved in four ways:

1. Save an active stream as an Excel file by pressing Save->Save XLS.
2. Save a selected stream as an Excel file by right-clicking and pressing the Save XLS button in the popup menu.
3. Save an active stream as an XML file by pressing Save->Save XML. In this case it also includes the current Mineral Setup.
4. Save a selected stream as an XML file by right-clicking and pressing the Save XML button in the popup menu.

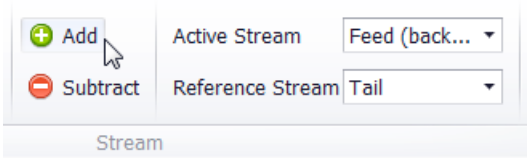
85.3.2. Copying a Stream

To copy a stream, right-click on the appropriate stream and select Copy from the pop-up menu. The created stream is named “Copy of”.



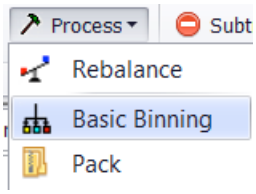
85.3.3. Add/Subtract a Stream

To add a stream to another, first define the reference stream. This is the stream to be added to the active stream. Then activate the stream and select Add.



To subtract one stream from another, define the Reference and the Active Stream as above and press Subtract.

85.3.4. Basic Binning



Basic binning is a basic classification routine. Particles are divided into groups according to size class and composition. For each size class, the following particle groups are created:

- Liberated - a single particle is created for each mineral, assigned the letter 'A' and a mineral index;
- Binary - for each pair of minerals, Binary Class particles are created;
- Ternary - for each ordered triplet of minerals, 6 particles are created (all possible permutations);
- Complex - a single particle is created for each mineral.

The original particles are "redistributed" among the created particle groups.

Choose the necessary stream as active and press Basic Binning. The result of the process depends on the settings (see Configuration) and on the following items:

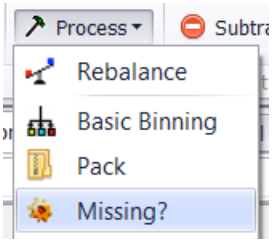
- **Lib Threshold** - Minimum amount of mineral in particle necessary to treat as liberated
- **Tolerance** - Minimum amount of mineral in particle necessary to treat as binary, ternary, complex
- **Binary classes** - Count of liberation classes in binary
- **Classif. Basis** – Basis for liberation

Basic Binning is a prerequisite for many of the following processes, and in these cases the program will offer to do Basic Binning before starting the process.

The graphics show the mode of occurrence of minerals right after basic binning only.

79	M.P.2.A.01	68.61064072	2	10-20 um	Gn	8.794184	8.794183738	61.55928617	3017	7.5	100	0
80	M.P.2.A.02	83.02028289	2	10-20 um	Sp	1.792895	1.792895145	12.55026602	1270	4	0	100
81	M.P.2.A.03	77.2648644	2	10-20 um	Qtz	0.461149	0.461148535	3.228039744	509	2.65	0	0
82	M.P.2.B.0102.01	112.3002434	2	10-20 um	Gn-Sp	0.168243	0.168243335	1.177703347	34	7.380471273	98.17042255	1.810055897
83	M.P.2.B.0102.02	122.5821571	2	10-20 um	Gn-Sp	0.121525	0.121524697	0.85067288	23	7.045955696	92.66316925	7.311375548
84	M.P.2.B.0102.03	112.6381824	2	10-20 um	Gn-Sp	0.118834	0.118833901	0.83183731	27	6.731892269	87.20800348	12.56483139
85	M.P.2.B.0102.04	139.0757298	2	10-20 um	Gn-Sp	0.146351	0.146350813	1.024455692	28	6.483975322	82.09167982	17.90832018
86	M.P.2.B.0102.05	129.3988856	2	10-20 um	Gn-Sp	9.793E-02	0.097934603	0.685542218	23	6.254925466	77.25085083	22.74914917
87	M.P.2.B.0102.06	129.4393291	2	10-20 um	Gn-Sp	0.116802	0.116802414	0.817616897	26	6.061246088	72.87404824	27.12414582
88	M.P.2.B.0102.07	151.9678284	2	10-20 um	Gn-Sp	9.691E-02	0.096905442	0.678338095	16	5.830850567	67.2843725	32.7156275
89	M.P.2.B.0102.08	117.4011423	2	10-20 um	Gn-Sp	5.232E-02	0.05232443	0.36627101	16	5.676250583	63.28060192	36.71939808
90	M.P.2.B.0102.09	111.0080393	2	10-20 um	Gn-Sp	5.84E-02	0.058396456	0.408775192	20	5.457127706	57.21721536	42.78278464
91	M.P.2.B.0102.10	109.026781	2	10-20 um	Gn-Sp	5.912E-02	0.059122684	0.413858789	23	5.299512324	52.54576449	47.45423551
92	M.P.2.B.0102.11	143.5444385	2	10-20 um	Gn-Sp	9.244E-02	0.092435579	0.64704905	23	5.151239399	47.89025277	52.10974723

85.3.5. Missing – Size fraction extrapolation / interpolation



Measuring fine particle sizes and coarse particle sizes is laborious and their analysis is not very reliable. HSC Geo provides a simple extrapolation / interpolation routine to create liberation information for size classes that have not been measured. The size class must exist in the Mineral Setup (Size page).

This requires that Basic Binning has been run. The number and types of particles in each size fraction must be identical.

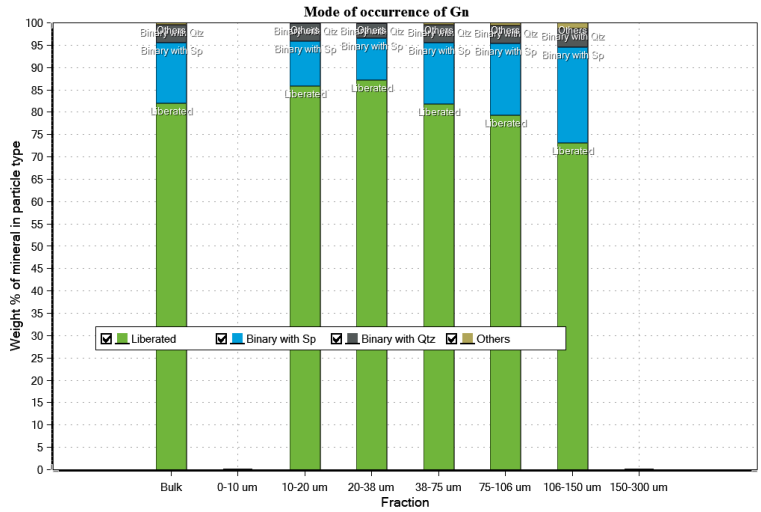
The weight parameter of the new particles is defined by the Weighted Least Squares with singular value decomposition (SVD) method by finding the Moore-Penrose pseudoinverse matrix. The parameters for the method are defined as follows:

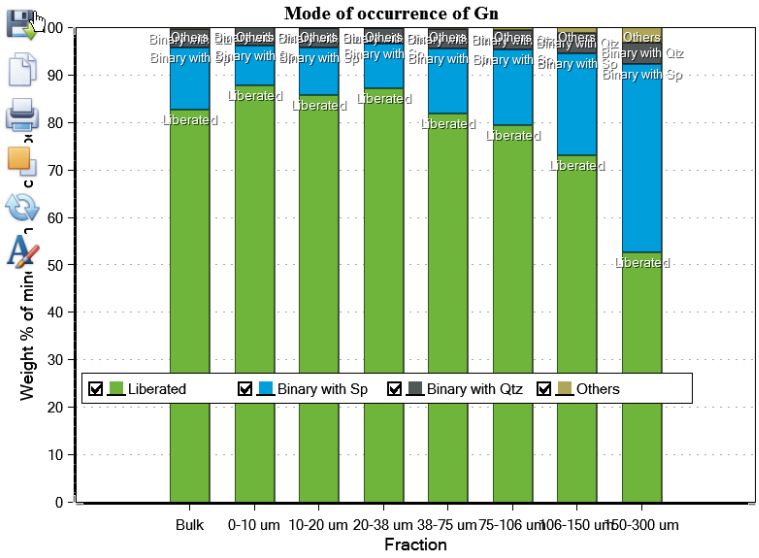
$$X = \text{average size of size class}, Y = \text{particle weight}, \sigma = \frac{1}{\sqrt{\text{NOP}}}.$$

The remaining particle parameters (NOP, mineral composition by weight%, mineral composition by volume%, mineral compositions by surface%) are defined as an average value of the corresponding parameters of the defined particles.

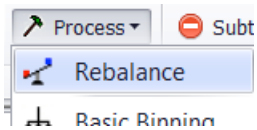
To run the procedure, choose the appropriate Stream (Active) and press Missing. If Basic Binning has not been run before, you will see a dialog window requesting permission to do so. After that, Missing will be done.

The figures below show the mode of occurrence of galena before and after the extrapolation, as liberation measurements were originally missing for two size fractions.





85.3.6. Rebalance



A routine that adjusts the mass proportion of particles (particle groups) so that the modal composition matches the one given on the Modal page.

Restrictions on particles: Particles must be specified for all size classes.

Choose the necessary Stream as active. Fill the Modal Composition sheet and press **Rebalance.** Basic Binning is a prerequisite; if not run before, a dialog will appear.

The termination of the process depends on the parameters (see **Configuration**):

- **Max Indiv. DIFF.** – Process is terminated if the difference in individual mineral grades is below the Max value
- **Max total DIFF.** – Process is terminated if the total difference is below the Max
- **Max Iter.** – Process is terminated once the maximum number of iterations is reached

85.3.7. Pack

The Pack process packs the particle data. It combines binary classes until the minimum number of particles in a class is reached.

Restrictions on particles: Only particles of the types A, B, C, D, and E are allowed. Particles are divided into groups according to size class. Each size class is processed separately. Type A particles are not modified. Other particles are divided into groups according to BegCode. Each BegCode is processed separately.

Particles are packed into groups. Particles are processed one by one; each particle can be added to the current group or to a new one according to the following rules:

- If the sum of **NOP** (number of particles) for the current group is less than **N min** (minimum particles), then the particle is added to the current group.
- If the particle has an **NOP** greater than **N min**, then the particle is added to a new group.
- If the particle is the last particle in the list, it is added to the current group.
- If the current group has more than one particle, the particle is added to a new group.
- If the next particle in the list has an **NOP** lesser than the sum of **NOP** for the current group, then the current particle is added to a new group.
- Otherwise the current particle is added to the current group.

If the processed particles have type B and the last group has less than **N min** particles, then it is merged with the previous group. After processing, each group is combined into a separate particle. After that, all C and D type particles that contain at least **N min** particles are combined into a single type E particle. In the ID of the new particle, the interval is defined by the number of combined particles.

Choose the necessary Stream as active and press **Pack**. The result of the process depends on the settings (see **Config**) and on **N Min** - the minimum number of particles required in a class.

85.3.8. Create Ref

Duplicates the Pack process; creates a reference stream to be used in packing other streams identically.

85.3.9. Bin with Ref

Applies basic binning of particles according to the particle classes in the reference stream. Choose the necessary streams as active and reference and press **Bin with Ref**.

This generates identical classes in the active stream as in the reference stream.

85.3.10. Smooth

This takes the stream, divides it by the reference stream, and then the particle distribution is smoothed against the reference.

Choose a necessary Stream as an active and press **Smooth**. The result of the process depends on the settings (see **Config**) and on the following items:

- List of regression types

- Smooth basis – basis for smoothing
- Equations applied in smoothing - If checked then binaries are smoothed alone without liberated particles; otherwise liberated particles are included in binary smoothing

85.3.11. Clean

Removes the particles with an **NOP** equal to zero.

Choose the necessary Stream as active and press **Clean**.

85.3.12. Randomize

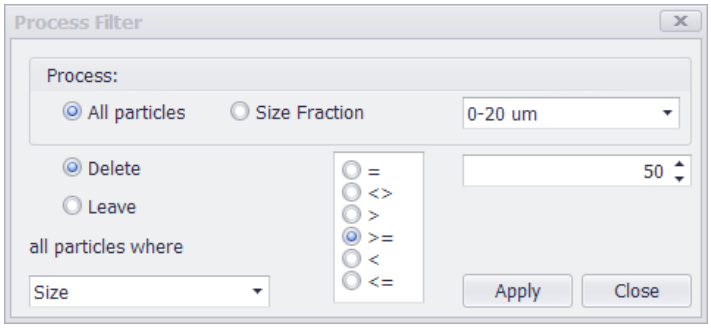
Randomly changes the weight parameter of the particles.

Choose the necessary Stream as active and press **Randomize.**

85.3.13. Filter

Filters the particles by user-set parameters.

It is possible to filter particles by size class, and remove or keep particles depending on the conditions.
The numeric properties of the particles are used for the conditions. The conditions can use one of the following binary relations: "=", "<>", ">", "=>", "<", "<="



Choose the necessary Stream as active and press **Filter**. A window with the filter settings will appear.

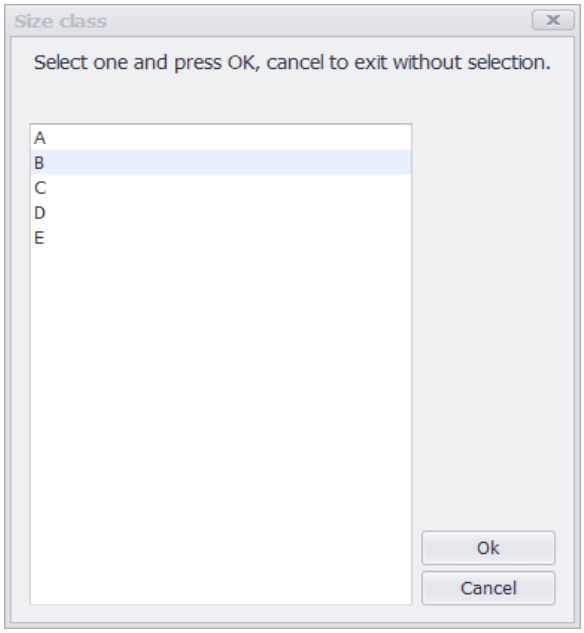
In the open window you can select:

- Particles for processing (all particles or a specific size class, which can be selected in the next field)
- Whether to delete particles or leave them
- Relations: "=", "<>", ">", "=>", "<", "<="
- Value to compare properties to
- Particle properties for filtering

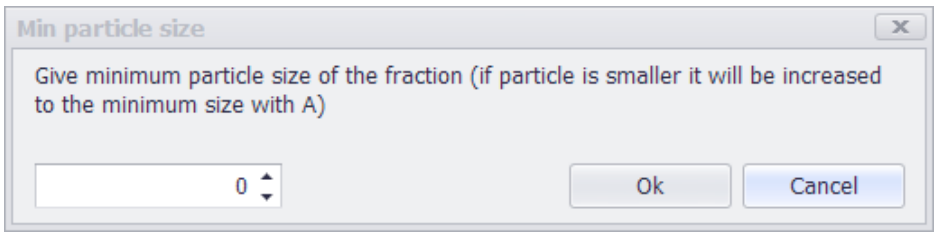
After setting up, you need to press **Apply** to apply the filter, or **Close** to cancel.

85.3.14. Fill Gangue

Changes the mineral composition by wt.% for particles that have a size less than the set value for the selected mineral group and selected size class.



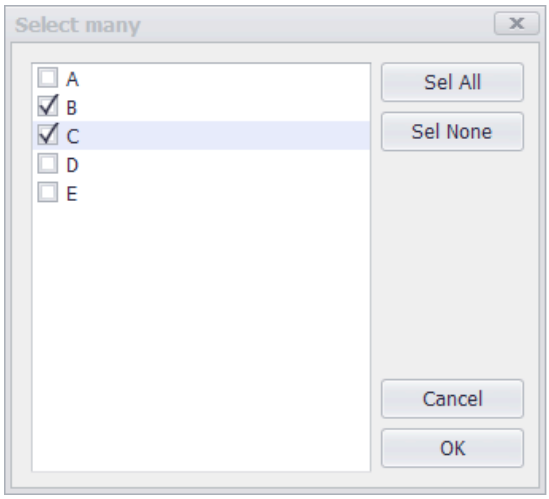
Choose the necessary Stream as active and press **Fill Gangue**. A window for the selection of size class will appear. Choose the necessary size class from the list and press **OK**. You will see a choice of mineral group window. Choose a mineral group and press **OK**. After that, the **Min Particles Size** window will appear. In this window you should enter a minimum particle size and press **OK**.

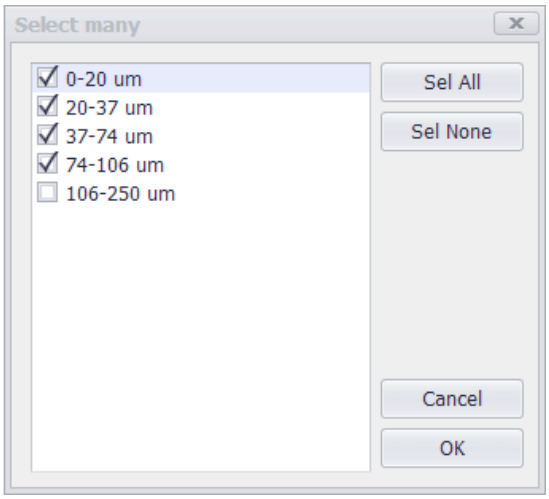


85.3.15. +Lib/-Lib

Increases (+Lib) or decreases (-Lib) the weight parameter for the liberated particles, for the selected size classes.

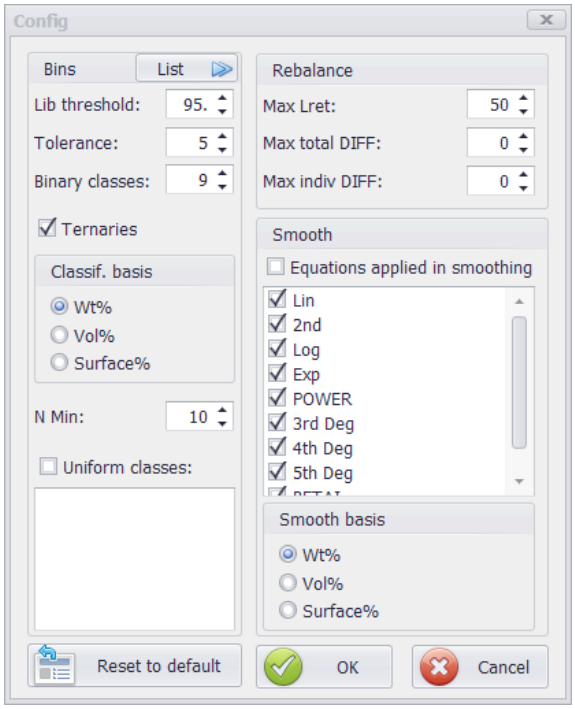
Choose the necessary Stream as active. Press **+Lib** or **–Lib** depending on the desired action. Two windows will open. In the first one it is necessary to select the required mineral groups; in the second one to select the size classes. Pressing **Sel All** will select all mineral groups or size classes. Pressing **Sel None** will clear the selection. After selecting the desired mineral groups and size classes, press **OK**.





85.3.16. Configuration

Clicking Config opens the configuration options of the active stream. Global Config shows the default parameters of the processes.



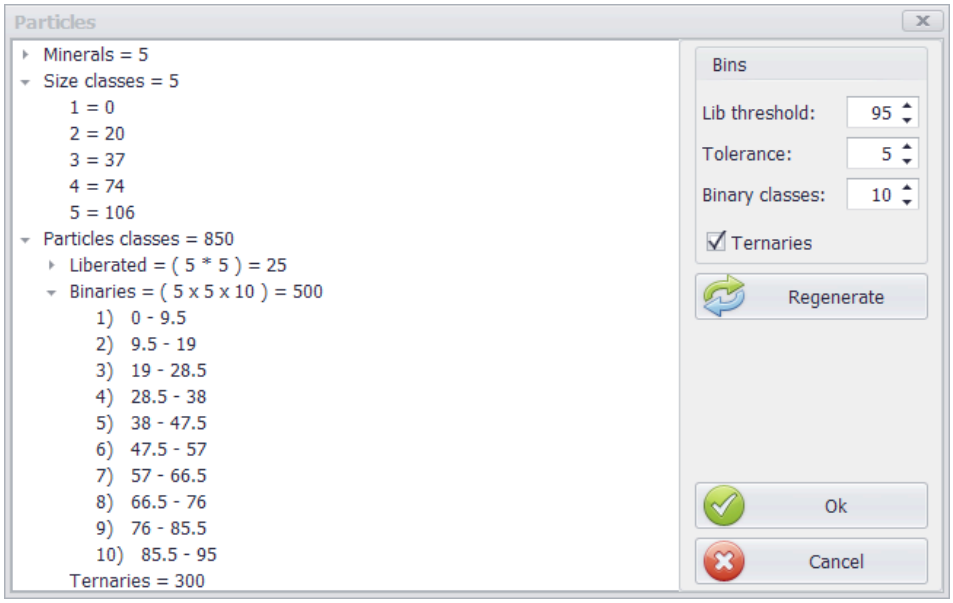
In this window, you can set the following options:

- Binning Config (Configuration for Basic Binning)
  - Lib. threshold - Minimum amount of mineral in the particle necessary to treat it as liberated
  - Tolerance - Minimum amount of mineral in particle necessary to treat it as binary, ternary, complex
  - Binary classes - Count of liberation classes in binary
  - Classif. basis
  - Ternaries - (6 particles are created for each ordered triplet of minerals)
  - N Min - Minimum number of particles required in a class
- Rebalance Config (Configuration for Rebalance)

- Max Indiv. DIFF - Max difference in individual minerals
- Max total DIFF - Max total difference in mineral amounts
- Max Iter. - Max iteration rounds in rebalancing

- Smooth Config (Configuration for Smooth)
  - List of regression types – some regression types
  - Smooth basis – basis for smoothing
  - Equations applied in smoothing - If checked then binaries are smoothed alone without liberated particles; otherwise liberated particles are included in binary smoothing

Clicking on the List button will show a window with Binning Config. In this window you can see the effect of the settings on the particles.



On the left, the tree obtained from the specified parameters is shown. By changing the parameters and clicking Regenerate, the tree will be rebuilt. Pressing OK will save the changes. Cancel undoes all changes. Clicking on the Reset to default button will reset the configuration to the global default.

In the fifth row you can see the number of mineral groups. The basic information about the group is given below:

- Code – mineral group name
- Mineral – main mineral in the group
- Includes – what minerals are in the group

After that, the following information is displayed:

- Number of behavioral types and name of each type for each mineral group
- Reference of each mineral group
- Specific gravity of each mineral group
- Chemical composition by wt.% (You can change this value)

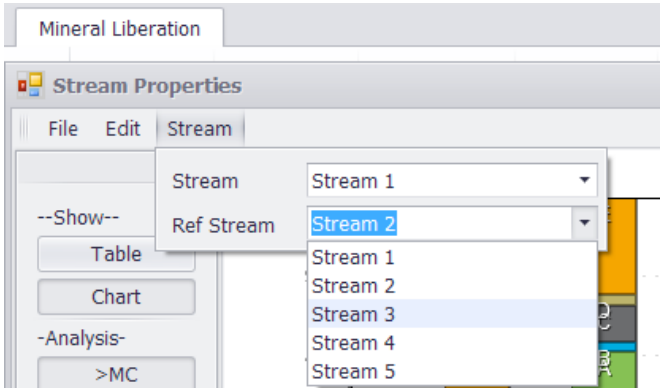
85.4. Graphics

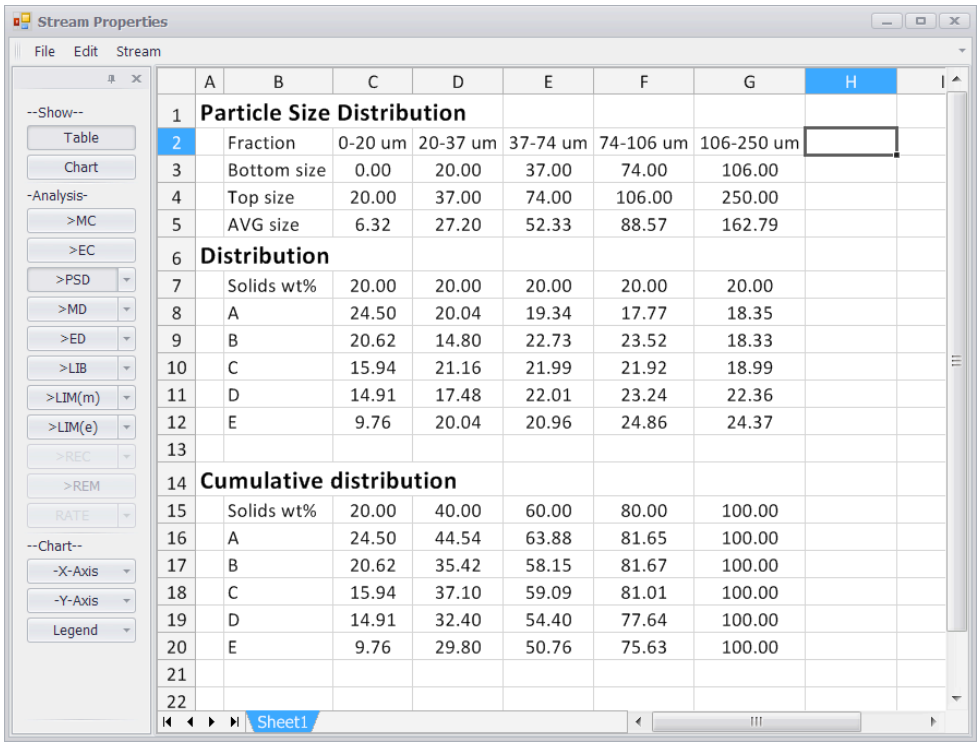
Pressing **Graphs** will open the stream analysis window. The result will be shown in the form of a chart or a table. To display the results as a table, press **Table;** to display the results as a chart, press **Chart** (by default the result is presented as a chart).

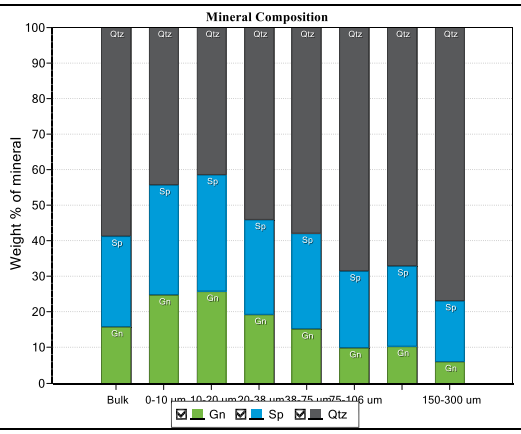
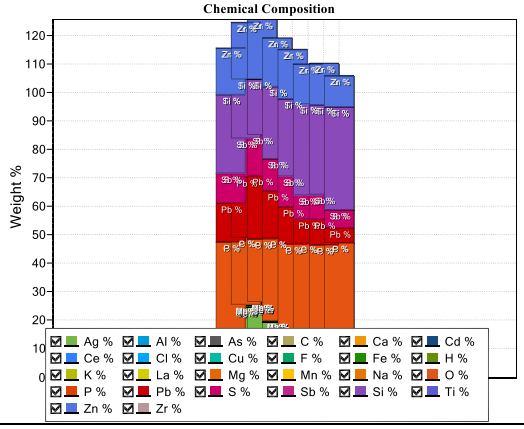
The following types of Stream analysis are available (corresponding to the buttons on the panel):

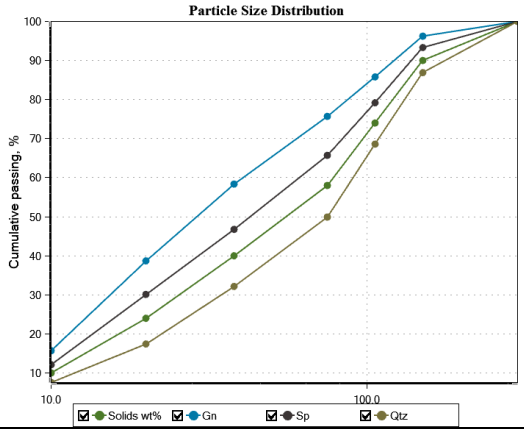
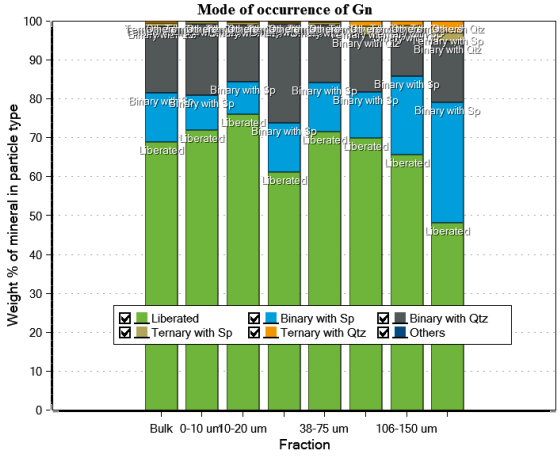
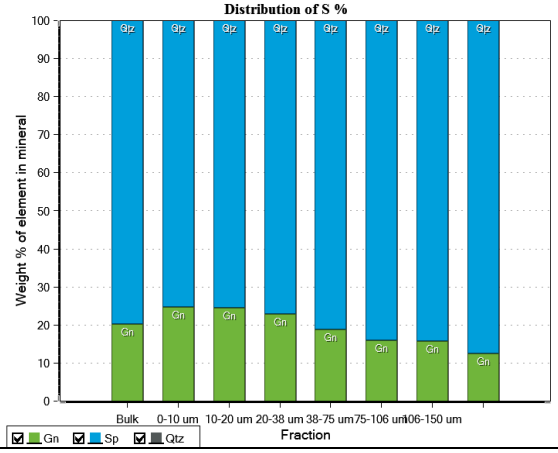
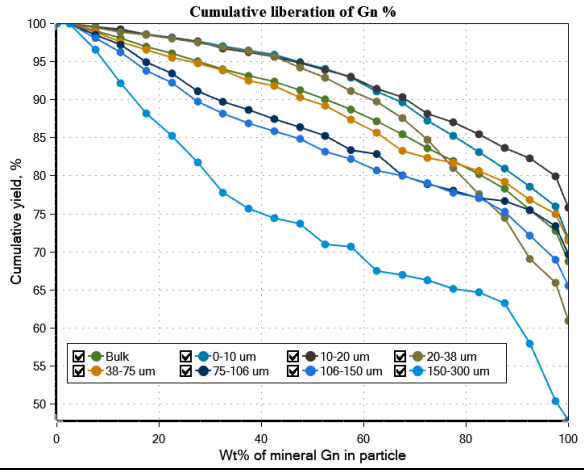
1. **MC** - Mineral (modal) composition (by size)
2. **EC** - Elemental composition (by size)
3. **PSD** - Particle Size Distribution (by mineral)
   In the dropdown menu it is possible to select **Cumulative** passing or **Continuous** passing.
4. **MD** - Mode of occurrence of mineral (by size)
   You can choose **Mineral** and less then combine classes
5. **ED** - Distribution of element between minerals (by size)
   You can choose **Element** for distribution
6. **LIB** - Cumulative liberation curves (by mineral)
   You can choose **Mineral** and **Liberation classes**. You can also check that the **first class is 100-100** (menu item)
7. **LIM** - Mineralogical limiting curves
   You can choose **Mineral** or **Element** and **Grade-Recovery** orientation

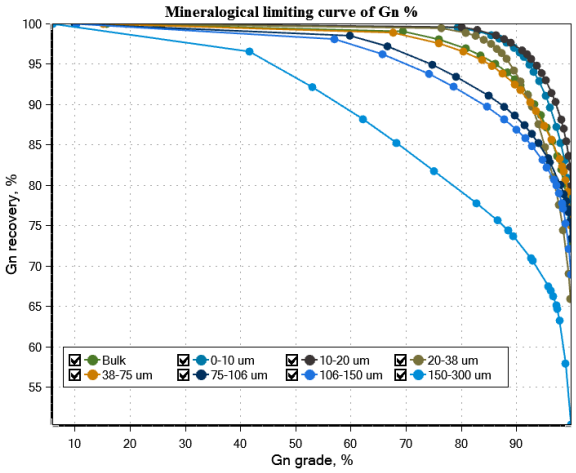
To change the **Active** and the **Reference Stream**, use the **Stream** menu, see below.





Modal composition	
Chemical composition	

Particle size distribution	
Mode of occurrence of mineral	
Distribution of elements	
Cumulative liberation yields	

Mineralogical limiting curves	

85.5. References

1. Fandrich, R. G., Gu, Y., Burrows, D., & Moeller, K. (2007). Modern SEM-based mineral liberation analysis. *International Journal of Mineral Processing*, *84*(1-4), 310–320. doi:10.1016/j.minpro.2006.07.018
2. Gu, Y. (2003). Automated Scanning Electron Microscope Based Mineral Liberation Analysis. *Journal of Minerals & Materials Characterization & Engineering*, *2*(1), 33–41.