84. Geo Module - Mineralogical Calculations and Mineral Database

84.1. Introduction

The Geo module of HSC is intended for:

- Studying mineral properties (Database Viewer, Catalogue: section 84.2, 84.4)
- Finding minerals based on elements in the formula (Find by Properties: 84.3)
- Identifying minerals based on the chemical composition (Find by Composition: 84.5)
- Performing petrological calculations (Petrological: 84.6)
- Calculating the modal composition (mineral composition) of samples based on chemical assays (Modal : 84.7)
- Processing mineral liberation data (Mineral liberation: 85)

Geo 1	Fools	
Mine	ral Database	^
<	Catalogue	
Q	Find by Properties	
7	Find by Composition	
3	Database Viewer	
Calc	ulations	^
h	Modal	
20	Mineral Liberation	
1	Petrological	

84.2. Mineral database

Press the Mineral database button to study the mineral database of HSC Chemistry.



84.2.1. Source

There are different sources for the mineral database. These can be selected as in figure below

HSC Geo - C:\H			qlite											
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ieo Tools		Catalogue	Mineral Databas	×										
Mineral Database	^	1												
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Tind by Com	nosition	Mineral ID		Mineral Name	Location	Mineral Key	Statistics	Reference	Sample No	Note 1	Note 2	Note 3		56
Database Vie			A C	-		-	-	× U c	, Uc	N U C	N U C	-	-	
	ewei		3 Tyc	Tychite	Borax Lake	Dana Vol II	Avg(2)					Dana Vol II	HSC	2.!
Calculations	^		4 Brad	Bradleyite	Wyoming	Dana Vol II		Deserved 11				Dana Vol II	HSC	2.7.
			5 Le	Leadhillite	Ganby, Missouri	Dana Vol II		Dana Vol II				Dana Vol II	HSC	6.4
Modal			6 Lg	Langbeinite	Mayo min, Punjab Salt Range	Dana Vol II, 2		Dana Vol ii				Dana Vol II, 2		2.8
Mineral Liber	ation		7 Lg	Langbeinite	Hall, Tyroll	Dana Vol II, 3		Dana Vol ii				Dana Vol II, 3		2.82!
Petrological			8 Lg 9 Mnsr	Langbeinite	Lea County, New Mexico	Dana Vol II, 4 Dana Vol II		Dana Vol ii Dana Vol II				Dana Vol II, 4	HSC	2.85
			9 Minsr 0 Gs	Minasragrite Gersdorffite	Minasragra Cobur mine			251				Dana Vol II		6.1
			1 Gs	Gersdorffite	Cochabamba, Bolivia	Anthony et al Anthony et al		251				Anthony et		6.1
			2 Gen	Genkinite	Onverwacht mine, South Africa	Anthony et al		251				Anthony et		8.8
			3 Gen	Genkinite	Shetland Islands, Scotland	Anthony et al		251				Anthony et		8.8
			4 GI	Gallite	Tsumeb, Namibia	Anthony et al		251				Anthony et		4.
			5 GI	Gallite	Tsumeb, Namibia	Anthony et al		251				Anthony et		4.:
			.5 Glk	Galkhaite	Gal-Haya, Russia	Anthony et al		251				Anthony et		5.4
			.7 Glk	Galkhaite	Kaidarkan, Russia	Anthony et al		251				Anthony et		5.4
			8 Glk	Galkhaite	Khaidarkan, Russia	Anthony et al		251				Anthony et		5.4
			9 Glk	Galkhaite	Getchell mine, Nevada, USA	Anthony et al		251				Anthony et		5.4
			0 Gn	Galena	Shaba Province, Zaire	Anthony et al		251				Anthony et		7.4
			1 Gn	Galena	Sadon Formation, Caucasus Mou	Anthony et al		251				Anthony et		7.4
			2 Gbmtt	Galenobismutite	Nordmark, Sweden	Anthony et al		251				Anthony et		1.
			13 Cr	Chromium	Sichuan Province, China	Anthony et al		251				Anthony et		7.:
			4 Crmf	Chromferide	Southern Urals, Russia	Anthony et al		251				Anthony et		/
			15 Ccp	Chalcopyrite	Western mines, Vancouver Islan	Anthony et al		251				Anthony et		4.:
			6 Cet	Cetineite	Cetine mine, Italy	Anthony et al		251				Anthony et		
			7 Paa	Paakkonenite	Kalliosalo Deposit, Finland	Anthony et al		251				Anthony et		5.2
rofile:			18 Mkn	Makinenite	Kuusamo, Finland	Anthony et al		251				Anthony et	HSC	7.2
HSC 9 👻	۱ ۱		9 Ltk	Laitakarite	Orijärvi mine, Finland	Vorma 1960		231				Vorma 1960	HSC	8.1:
					sign in the primers							1000		6.1.
Outotec		Hei ee e Re	cord 1 of 10972	► ₩ 4 ⊂	·			-		-		-		

- Mineral Chemistry = Table of the chemical composition of minerals (different analyses of minerals from different locations)
- Phase Chemistry = Table of chemical compositions of different compounds

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- Mineral = Table of minerals, one row per mineral
- Element = Chemical elements
- Mineral Dissolution = Table of mineral dissolutions alongside with method of analysis and the fraction extracted

After selecting the source you can apply:

- Filter
- Search
- Edit
- 84.2.2. Filter



By clicking the filter icon *Filter*, a new "Filter" window will appear in the right hand panel. You can then write a text in any of the fields in the top row. The small green "ABC" icon

beside the text can be pressed to choose the search criteria. The resulting search R B C criteria will be shown in the "Filter" window.

For instance, we want to search sphalerite minerals in all locations starting with the letter "S". Type the Mineral Name = "Sphalerite" and the Location = "S". By default the search criteria will then be all mineral names containing the word "Sphalerite" in all locations containing the letter "S". To change this click the "ABC" icon under the Location column to define the criteria as "Begins with" the letter "S". The search criteria is visualized in the Filter Window. There are a total of 10 records that fulfill the search criteria

	Enter text to :	search			▼ Find C	lear						Visual	Text	
	Mineral ID	Mineral Symbol	Mineral Name	Loca		Mineral k	·	Charlen	Reference	Sample No	Note 1	And O		
,	mineral ID	Mineral Symbol		Local		REC	key	Statistics	Reference	sample INO	Note 1		neral Name] Contains Sphalerite cation] Begins with S ③	0
	5171	-	Sphalerite	Cor 2	Clear Filter		al. 1	n u s	Viets et al,	n 🛄 c	Brown orang	leoc	cadorij begina widra @	
	5171		Sphalerite	-			al. 1		Viets et al,		Black-band			
	5185		Sphalerite		Equals		al. 1		Viets et al,		Colorless t			
	5180		Sphalerite	≠	Does not equal	-	al. 1		Viets et al,		Blue green			
	5188		Sphalerite	RBC	Contains		al. 1		Viets et al,		Yellow			
	5189		Sphalerite	828	Does not contain		al. 1		Viets et al,		Brown			
	5190		Sphalerite	8%C	ls like		al. 1		Viets et al,		Orange			
	5349		Sphalerite	R%C	ls not like	loro,	HOM		Anthony et					
	5460	Sp	Sphalerite	Rec	Begins with	Martin	ı	avg.	IMMSA					
	5470	Sp	Sphalerite		Ends with	Barba	ra	avg.	IMMSA					
				>	Is greater than Is greater than or equal to Is less than Is less than or equal to									

In the Filter Window you can:

- · Edit the field by clicking the Field value given in blue and selecting a new one from the list, e.g. changing [Mineral Name] to [Mineral Symbol].
- Edit the condition given in green and selecting a new one from the list, e.g. changing "Contains" to "Begin With"
- Edit the operator given in red and selecting a new one from the list, e.g. changing "And" to "Or"

• Adding or deleting a search criteria. Alternatively you can clear all search criteria at once by pressing clear.

S									Filter
Enter text to s	earch		▼ Find	Clear					Visual Text
									And O
Mineral ID	Mineral Symbol	Mineral Name	Location	Mineral Key	Statistics	Reference	Sample No	Note 1	[Location] Begins with S 😳
=	ROC	Sphalerite	BC S	я∎с	R C	R C	R C	ROC	[Mineral Name] Contains Sphalerite
5171	Sp	Sphalerite	Sweetwater, Viburnum Trend	Viets et al. 1		Viets et al,		Brown orang	
5185	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Black-band	
5186	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Colorless t	
5187	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Blue green	
5188	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Yellow	
5189	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Brown	
5190	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Orange	
5349	Sp	Sphalerite	Sonoro	Sonoro, HOM		Anthony et			
5460	Sp	Sphalerite	S. Martin	S. Martin	avg.	IMMSA			
5470	Sp	Sphalerite	S. Barbara	S. Barbara	avg.	IMMSA			

To copy data to the clipboard, select the rows you want to copy (use Ctrl or Shift to select several rows) and press "Copy Data." Alternatively you can press the keyboard shortcut Ctrl + C.

Copy Data Mineral Cher Braste Data Mineral Mineral		÷ ∓ ∓ Vi	ew / Edit	Add Record Remove Record (s)	Filter						About	Help Rest
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Mineral Database ^	0	i470	<i></i>								Filter	
Catalogue	Er	iter text to	search		▼ Find	Clear					Visual Text	
Find by Properties	M	ineral ID	Mineral Symb	ool Mineral Name	Location	Mineral Key	Statistics	Reference	Sample No	Note 1	- [Location] Begins with S	0
Find by Composition	9	-	a 🗖 c	I Sphalerite	🚺 ac S	A C	# I C	s∎c	a 🗖 c	* 0 ¢	[Mineral Name] Contains	s Sphalerite 😳
3 Database Viewer		5171	Sp	Sphalerite	Sweetwater,Viburnum Trend	Viets et al. 1		Viets et al,		Brown orang		
Calculations ^		5185	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Black-band		
Calculations		5186	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Colorless t		
Modal		5187	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Blue green		
Mineral Liberation		5188	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Yellow		
Petrological		5189	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Brown		
		5190	Sp	Sphalerite	Stoeker mine, C. Missouri	Viets et al. 1		Viets et al,		Orange		
		5349	Sp	Sphalerite	Sonoro	Sonoro, HOM		Anthony et				
		5460	Sp	Sphalerite	S. Martin	S. Martin	avg.	IMMSA				
Profile:	•	5470	Sp	Sphalerite	S. Barbara	S. Barbara	avg.	IMMSA				
HSC 9 -	144 44	 Record 	d 10 of 10 ⊧	н ні ч — — — — — — — — — — — — — — — — — —						÷.		
	x	/ Starte w	ith(flocation].	'S') And Contains([Minera	Name], 'Sphalerite') 👻						Clear	

84.2.3. Find

You can search through the database by entering the keyword and clicking Find. Find differs from Filtering in that it always searches all the fields and it always seeks matches with any part of the field.

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0	4787												
	Bushveld			▼ Find C	lear								
	Mineral ID	Mineral Symbol	Mineral Name	Location	Mineral Key	Statistics	Reference	Sample No	Note 1	Note 2	Note 3	Database	3
q	-	R C	REC	R C	R O C	s C	8 🖬 C	#IC	a 🗖 c	a 🗖 c	A B C	ROC	
•	4787	Ves	Vesuvianite	Bushveld, S.Africa	DHZ, Vol:1A,		Deer et al.,				DHZ, Vol:1	HSC	
	12787	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Cabri et al				Cabri 2002	HSC	
	12788	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Cabri et al				Cabri 2002	HSC	
	12789	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Kingston a				Cabri 2002	HSC	
	12790	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Verryn and				Cabri 2002	HSC	
	12791	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Brynard et				Cabri 2002	HSC	
	12792	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Schwellus e				Cabri 2002	HSC	
	12793	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Cabri and L				Cabri 2002	HSC	
	12794	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Barokov et				Cabri 2002	HSC	
	12795	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Criddle and				Cabri 2002	HSC	
	12796	Brag	Braggite	Bushveld Complex, Republic of S	Cabri 2002 T		Auge and L				Cabri 2002	HSC	
	13208	OI	Olivine	Western Bushveld complex, Sout	1/Table2		3614				1/Table2	HSC	

You can write several searches by separating them with a space, e.g. writing DHZ biotite will show all the fields containing the text DHZ or biotite (see below).

4787												
DHZ Biotite			• F	ind Clear								
Mineral ID	Mineral Symbol	Mineral Name	Location	Mineral Key	Statistics	Reference	Sample No	Note 1	Note 2	Note 3	Database	5
=	ROC	REC	8 II C	R C	RBC	REC	R C	я∎с	R O C	R C	REC	-
5102	Pg	Paragonite	Glebe Mountain, Vermor	nt DHZ, Vol:3,p		Deer et al.,		In chlorite		DHZ, Vol:3,	HSC	
5103	Glt	Glauconite	Kakako Creek, Otago	DHZ, Vol:3,p		Deer et al.,		In sandstone		DHZ, Vol:3,	HSC	
5104	Phi	Phlogopite	Anxiety Point,New Zeal	and DHZ, Vol:3,p		Deer et al.,		In marble		DHZ, Vol:3,	HSC	
5105	Bt	Biotite	S.California Batholith	DHZ, Vol:3,p		Deer et al.,		In norite		DHZ, Vol:3,	HSC	
5106	Bt	Biotite	Liruei, Northern Nigeria	DHZ, Vol:3,p		Deer et al.,		In granite		DHZ, Vol:3,	HSC	
5191	Bt	Biotite	Glen Esk, Scotland	DHZ, Vol:3,p		Deer et al.,				DHZ, Vol:3,	HSC	
5192	Lpd	Lepidolite	Varuträsk, Sweden	DHZ, Vol:3,p		Deer et al.,		In pegmatite		DHZ, Vol:3,	HSC	
5194	Mrg	Margarite	Pennsylvania	DHZ, Vol:3,p		Deer et al.,				DHZ, Vol:3,	HSC	
5195	Cln	Clintonite	Urals	DHZ, Vol:3,p		Deer et al.,				DHZ, Vol:3,	HSC	
5196	Stp	Stilpnomelane	Zuckmantel, Silesia	DHZ, Vol:3,p		Deer et al.,		Vein		DHZ, Vol:3,	HSC	
5197	Stp	Stilpnomelane	SJ Bautista Mine, Califor	DHZ, Vol:3,p		Deer et al.,				DHZ, Vol:3,	HSC	
5198	Prl	Pyrophyllite	Honami Mine, Japan	DHZ, Vol:3,p		Deer et al.,				DHZ, Vol:3,	HSC	
5199	Tlc	Talc	Muruhatten, Sweden	DHZ, Vol:3,p		Deer et al.,		In altered		DHZ, Vol:3,	HSC	
5200	Chl	Chlorite	Aorere, New Zealand	DHZ, Vol:3,p		Deer et al.,		Sheridanite		DHZ, Vol:3,	HSC	
5201	Cch	Clinochlore	West Town, Pennsylvar	ia DHZ, Vol:3,p		Deer et al.,		Chlorite		DHZ, Vol:3,	HSC	
5203	Ams	Amesite	Chester, Massachusset	DHZ, Vol:3,p		Deer et al.,		Septechlorite		DHZ, Vol:3,	HSC	
5204	Ctl	Chrysotile	Quebec, Canada	DHZ, Vol:3,p		Deer et al.,		Serpentine		DHZ, Vol:3,	HSC	
5205	Atg	Antigorite	Cropp river, New Zealar	DHZ, Vol:3,p		Deer et al.,		Serpentine		DHZ, Vol:3,	HSC	
5206	Kln	Kaolinite	Mesa Alta, New Mexico	DHZ, Vol:3,p		Deer et al.,		Containing		DHZ, Vol:3,	HSC	
5207	Dck	Dickite	Schuylkill, Pennsylvania	DHZ, Vol:3,p		Deer et al.,				DHZ, Vol:3,	HSC	
5208	III	Illite	Fithian, Illinois	DHZ, Vol:3,p		Deer et al.,				DHZ, Vol:3,	HSC	
5209	III	Illite	South Wales	DHZ, Vol:3,p		Deer et al.,		Hydomusco		DHZ, Vol:3,	HSC	
5210	Glt	Glauconite	Whare Flat, New Zealar	d DHZ, Vol:3,p		Deer et al.,		In sandstone		DHZ, Vol:3,	HSC	
5211	Mnt	Montmorillonite	Montmorillon, France	DHZ, Vol:3,p		Deer et al.,		In shale		DHZ, Vol:3,	HSC	
5212	Rei	Beidellite	Black Jack Mine, Idaho	DHZ. Vol:3.p		Deer et al				DHZ, Vol:3	HSC	

84.2.4. Edit

To edit the database, press View / Edit in the ribbon (top).

🖹 Copy Data 隆 Paste Data	Mineral Chemistry Phase Chemistry Mineral	4 ►	View / Edit	H Add Record
Clipboard	Database Table			Editing

The database view color will change to orange, indicating that the database is in edit mode. Pressing the View/Edit button again will change the database to the view mode and the color to white.

Editing the content of a row

Activate the row and cell you want to edit and just type the new value in the cell. Change the cursor position and the value will be automatically saved in the database.

Deleting a row

Select the row you want to delete and press "Remove Record(s)". Geo will ask you to confirm the removal.

- Copy Data	l Chemistry Chemistry	- 		Add Record Remove Record (s)	Filter								About	Help	S Restore
Clipboard Da	tabase Table		Editir	Ig	Filter									Help	
Geo Tools	Cat	alogue	Mineral Databas	e ×											
Mineral Database	^ 🕡 B	ushveld, S	outh Africa												
Catalogue						▼ Find	Clear								
Find by Properties		1.00	10 10 11												
(7) Find by Composition		ineral ID	Mineral Symbol	Mineral Name	Location		Mineral Key	Statistics	Reference	Sample No	Note 1	Note 2	Note 3	Database	2
Database Viewer	9 =		1 0 0	a ⊡ c	ROC		R C	*Oc	* 0 ¢	n∎c	A D C	n O C	R O C	ROC	
Database viewer	Ø.		7 Ves	Vesuvianite	Bushveld, S		DHZ, Vol: 1A,		Deer et al.,				DHZ, Vol:1		
Calculations			3 Sil	Sillimanite		Pennsylvania	DHZ, Vol: 1A,		Deer et al.,				DHZ, Vol:1	HSC	
			9 Mul	Mullite	Argyllshire,		DHZ, Vol: 1A,		Deer et al.,				DHZ, Vol: 1	HSC	
Modal			0 And	Andalusite	South Dako		DHZ, Vol: 1A,		Deer et al.,				DHZ, Vol:1		
Sineral Liberation			1 Knn	Kanonaite	Kanona, Za		DHZ, Vol: 1A,		Deer et al.,				DHZ, Vol:1		
Petrological			3 Toz	Topaz	Thomas Ra		DHZ, Vol: 1A,		Deer et al.,		In rhyolite		DHZ, Vol:1		
		479-	4 St	Staurolite	Fiordland, 1	lew Zealand	DHZ, Vol: 1A,		Deer et al.,		In amphibolite		DHZ, Vol:1	HSC	
		479	5 St	Staurolite	Saarikoski,	Sodankyla	DHZ, Vol: 1A,		Deer et al.,		In schist		DHZ, Vol:1	HSC	
		479	5 St	Staurolite	Oquossoc a	rea, Maine	DHZ, Vol: 1A,		Deer et al.,				DHZ, Vol:1	HSC	
		479	7 Cld	Chloritoid	Patom Upla	nds, USSR	DHZ, Vol: 1A,		Deer et al.,		In schist		DHZ, Vol:1	HSC	
		479	3 Cld	Chloritoid	Broken Hill,	Australia	DHZ, Vol: 1A,		Deer et al.,		In schist		DHZ, Vol:1	HSC	
		479	9 Cld	Chloritoid	Rawlinsville	,Pennsylvania	DHZ, Vol: 1A,		Deer et al.,				DHZ, Vol:1	HSC	
		480) Zo	Zoisite	Kanasaki di	strict, Japan	DHZ, Vol: 18,		Deer et al.,				DHZ, Vol:1	HSC	
		480	1 Zo	Zoisite	Saualpe, Ar	ustria	DHZ, Vol: 18,		Deer et al.,		In edogite		DHZ, Vol:1	HSC	
		4803	2 Czo	Clinozoisite	Kalvia, Finla	ind	DHZ, Vol: 18,		Deer et al.,		In quartzite		DHZ, Vol:1	HSC	
		480	3 Czo	Clinozoisite	Italian Wes	tern Alps	DHZ, Vol: 18,		Deer et al.,		In glaucop		DHZ, Vol:1	HSC	
		480-	4 Ep	Epidote	Cornwall, E	ngland	DHZ, Vol:18,		Deer et al.,		In calc silic		DHZ, Vol:1	HSC	
		480	5 Ep	Epidote	Pikkaranta		DHZ, Vol: 18,		Deer et al.,				DHZ, Vol:1	HSC	
		480	5 Ep	Epidote	Takeshi, Ja	pan	DHZ, Vol: 18,		Deer et al.,				DHZ, Vol:1	HSC	
		480	7 Pie	Piemontite	Glen Coe, S	cotland	DHZ, Vol:18,		Deer et al.,		In andesite		DHZ, Vol:1	HSC	
Profile:		480	8 Pie	Piemontite	Piemonte, I	taly	DHZ, Vol:18,		Deer et al.,				DHZ, Vol: 1	HSC	
		480	9 Aln	Allanite	Michalkowo	, Bulgaria	DHZ, Vol: 1B,		Deer et al.,				DHZ, Vol:1	HSC	
HSC 9 🔻		481) Aln	Allanite	Transbaikal	, USSR	DHZ, Vol: 18,		Deer et al.,		In pegmatite		DHZ, Vol:1	HSC	
	144 44	 Reco 	rd 4544 of 10972	► ₩ H <											÷.
Outotec															

ISC Geo		
Are you	sure?	
[e	No	Cancel



Adding a new row by manually typing

Press "Add Record" on the right panel or in the ribbon. A new window will show in which you can enter the new record. You can add new field for the new record by pressing "Add Field".

		📾 Add Re	cord	Add Reco	rd			X
v	iew / Edit	Remove	e Record (s)	Source:	Minera	al Chemistry		-
		Editing		Mineral Na	me	Sphalerite		
_	_			Mineral	ID		0	
e	Mineral D	atabase X		Locatio	n		New Mine	
rite				Mineral	Key		Ref: Report 121	
				Refere	nce			
				SG				
						5		
ID	Mineral Sy	mbol Mine	eral Name 🏾 📍	Add	Field		🕄 Add Record 🧲	Cancel
	100		Calculation					

Geo creates a new row at the end of the table. Geo will also automatically fill in the Mineral Symbol fields.

	Mineral ID	Mineral Symbol	Mineral Name	Location	Mineral Key	Statistics	Reference	Sample No	Note 1	Note 2	Note 3	Database
٩	=	R D C	R O C	s ⊡ c	R O C	a 🗖 c	R C	R O C	R C	R O C	R C	R O C
	12625	Sp	Sphalerite	Pyhäsalmi	E corner		3595		Deep Ore, I		E corner	HSC
	12626	Sp	Sphalerite	Pyhäsalmi	W ore		3595		Deep Ore, I		W ore	HSC
	12627	Sp	Sphalerite	Pyhäsalmi	Galena veins		3595		Deep Ore, I		Galena veins	HSC
	12666	Sp	Sphalerite	Lampisaari mine, Vihanti	Lampinsaari,		3596		no. of anal		Lampinsaar	HSC
	12667	Sp	Sphalerite	Lampisaari mine, Vihanti	Sotka 1981		3596		no. of anal		Sotka 1981	HSC
	12668	Sp	Sphalerite	Lampisaari mine, Vihanti	Sotka 1981		3596		no. of anal		Sotka 1981	HSC
	12685	Sp	Sphalerite	Talvivaara deposits, Sotkamo, Ka	Törnroos 1982		3598				Törnroos 1	HSC
	12715	Sp	Sphalerite	Talvivaara deposits, Sotkamo, Ka	Loukola-Rusk		3600				Loukola-Ru	HSC
	12722	Sp	Sphalerite	Pahtavuoma, Kittilä, Central Lapl	Papunen 1987		3601	Pv-2 14.60			Papunen 1	HSC
	12723	Sp	Sphalerite	Pahtavuoma, Kittilä, Central Lapl	Papunen 1987		3601	Pv-2 18.00			Papunen 1	HSC
	12724	Sp	Sphalerite	Pahtavuoma, Kittilä, Central Lapl	Papunen 1987		3601	Pv-2 32.00			Papunen 1	HSC
	12725	Sp	Sphalerite	Pahtavuoma, Kittilä, Central Lapl	Papunen 1987		3601	Pv-5 19.50			Papunen 1	HSC
	12726	Sp	Sphalerite	Pahtavuoma, Kittilä, Central Lapl	Papunen 1987		3601	Pv-5 46.00			Papunen 1	HSC
	12727	Sp	Sphalerite	Pahtavuoma, Kittilä, Central Lapl	Papunen 1987		3601	Pv-129 33.50			Papunen 1	HSC
	13206	Sp	Sphalerite	Babbitt deposit, Minnesota, USA	29/Table2		3613				29/Table2	HSC
	13207	Sp	Sphalerite	Babbitt deposit, Minnesota, USA	30/table2		3613				30/table2	HSC
	13281	Sp	Sphalerite	Ottawa/Oklahoma, USA	2/table2		3618		High iron		2/table2	HSC
	13282	Sp	Sphalerite	Ottawa/Oklahoma, USA	3/Table2		3618		Low iron		3/Table2	HSC
	13300	Sp	Sphalerite	Thierry mine, Ontario, Canada	8/table2		3619				8/table2	HSC
	13301	Sp	Sphalerite	Thierry mine, Ontario, Canada	9/table2		3619				9/table2	HSC
	13336	Sp	Sphalerite	New Mine	Ref: Report							

Adding a new row by pasting

The easiest way of adding new mineral rows to the Geo mineral database is to organize the table (e.g. in Microsoft Excel) and paste it into Geo.

When organizing the data, you need to comply with the following rules:

- Data must be horizontal, one record per row
- The first row must give the field (column) names
- The column names must be exactly the same as in the Geo mineral database
- Information is required for at least the Mineral Name, Location, and Mineral Key columns

Select the data in Excel and in Geo select Paste Data. Alternatively, the keyboard shortcut Ctrl + V can be used

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September	6.	2023
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1	А	В	С	D	E	F	G	Н	<u> </u>	J
1	Mineral Nam	e Location	Mineral Key	Fe %	Zn %	S %	Cd %	CuO %	In ppm	
2	Sphalerite	Test	test	6.22	59.9	32.2	0.01	0.02	200	
3	Pyrite	Test	test	45		55	0.01		100	
4	¢									
5										
_	F	1ineral Chemis Phase Chemistr 1ineral	ry -		🕮 Add Recor					
(Clipboard	Database Ta	ble	E	diting					

Geo will advise how many rows were added and how many columns were identified. For example, the columns CuO % and In ppm were not identified and the data were not entered into the database. Copper values should have been given as Cu % and indium as In % for a successful paste.

HSC Ge	
	Columns identified: 7 of 9 Rows added: 2 of 2
	OK

84.3. Find by Properties

"Find by Properties" is used to find minerals based on elements in their formula.

Press "Find by Properties"

Mine	eral Database	^
	Catalogue <u>Find by Properties</u> Find by Composition Database Viewer	
Calc	ulations	^
h	Modal	
20	Mineral Liberation	
Ē	Petrological	

In the periodic table, click once on the elements that are found in the mineral (shown in yellow) and twice for elements that are not in the mineral (shown in red). Pressing Apply Filter will make a query in the mineral database and show those that pass the criteria. The query conditions can be seen either in visual or text output below the periodic table.

An example of minerals containing Cu, Cl, and O but not B, N, Na, Mg, S, K, Ca, Fe, Zn, Pb, and Bi is shown below.

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r i	ta	La	Ce	Pr No	i	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb	Lu
		Ac	Th I	Pa U		Np	Pu	Am	Cm	Bk	Cf	Es				
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Not Conta '\S\') ults	ins([Elements	, '\N\') And No	t Contains([Eleme	ents], '\Bi\') A	nd Not C	Contains([E	Elements], \	Pb\') And Co	ntains([Ele	ements], '\Cl	(') And Not	Contains([Elements],	Cle		Ŭ
Not Conta '\S\') ults	Name	, '\N\') And No	t Contains([Eleme	ents], '\Bi\') A	nd Not C	Contains([E	Elements], \ Genera Name	Pb\') And Co Il Propertie	ntains([Ele	ements], '\Cl	(') And Not	Contains([Elements],	Cle	ear Filter (wt-%)	Ŭ
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Not Conta \S\') ults d 12 21	Name 9 Anthonyite 5 Atacamite	Symbol Attn Ata	Formula Cu(OH,Cl)2 Cu2Cl(OH)3	ents], '\Bi\') A	nd Not C	Contains([E	Elements], '\ Genera S Name H Symb H Form Empir	Pb\') And Co Il Propertie	Antho Athn Cu(OF	ements], '\Cl	() And Not	Contains([Elements],	Cle		Ŭ
Not Conta \S\') ults d 12 21 42	Name 9 Anthonyite 5 Atacamite 3 Botallackite	Symbol Athn Ata Bot	Formula Cu(OH,CI)2 Cu2Cl(OH)3 Cu2Cl(OH)3	Empirical F Cu(OH) 1. 5.	. Grou	p	Elements], "\ Genera S Name H Symb H Form H Empir H Group	Pb\') And Co il Propertie e sol ula rical Formula p	Antho Athn Cu(Oł	ments], \Cl onyite H,Cl)2*3(H2 H) 1.5Cl0.5*	() And Not	Contains([Elements],	Cle	(wt-%)	Ŭ
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Not Conta '\S\') ults d 12 21 42 53 71	Name 9 Anthonyite 5 Atacamite 3 Botallackite 2 Calumetite 1 Claringbulli	Symbol Athn Ata Bot Calu e Clar	Formula Cu(OH,G1)2 Cu2Cl(OH)3 Cu2Cl(OH,G1)2 Cu2Cl(OH)3 Cu2Cl(OH,G1)2 Cu2Cl(OH,G1)2 Cu2Cl(OH,G1)2	Empirical F Cu(OH) 1. 5.	. Grou	p	S Name H Symb H Grou H Symb H Symb H Symb	Pb\') And Co il Propertie e sol ula rical Formula p pol Ref	Antho Antho Athn Cu(Oł Cu(Oł HSC(E	ements], \Cl onyite H,Cl)2*3(H2 H)1.5Cl0.5*	() And Not	Contains([Elements],	Cle	(wt-%)	Ŭ
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And No	r 118 / 310 f 525 (551 (648 (781 (980 f 1147 f 1231 (1334 (1483 f	Name Anglesite Betekhtinite Caracolite Caracolite Caracolite Chenite Corkite Elyite Fleischerite Galena Grandreefite	Symbol Angl Bvr Btk Cale Car Chne Crk Ely Fils Gn Gran	Formula PbSO4 PbCu(Fe,AI Cu10(Fe,P PbSCu2(C PbSCu2(C Pb4Cu(SO4 PbFe3(PO4 PbFe3(PO4 Pb5cs(SO4 Pb3Se(SO4 Pb5 Pb2(SO4)F2	Empirical F	Group Barite Alunite Beudanc	S	General Nam Symi Form Empi Grou Symi Note Com Dens Ore Dens Colo Harco Lusto Mag Mag Form	al Propert e bol nula irical Formu p bol Ref e position ents Mineral sity r fness er Susc Unitle	ies Angle Angl PDSO- ia Barite HSC(B O=21 VPb(SI VP	site 4 : :.103; S=1 \O\ 3	×	lemental	Compositi	Cle		Apply Filter

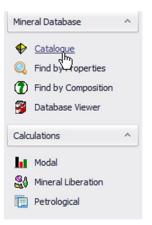
Another example of the search for lead-bearing sulfides is shown below.

The details of the resulting minerals are readily available in the lower panels. By selecting one row, the general properties of that mineral can be seen, alongside with the chemical composition graph. Example here is shown for Anglesite.

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84.4. Catalogue

The Catalogue button gives access to mineral properties by name.

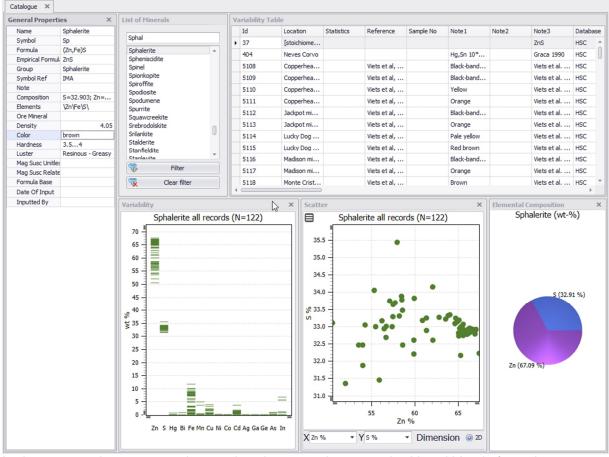


In the List of Minerals window, type the names of the mineral of interest (e.g. sphal... for sphalerite) and Geo will select the first mineral that matches the text you typed. The general properties of minerals are on the left and there is a table with different analyses of the selected mineral from the different locations shown on the right. By default, three graphs are given: elemental composition pie chart, scatter plot between different elements, and variability of the elements. This can be turned on and off in the top ribbon

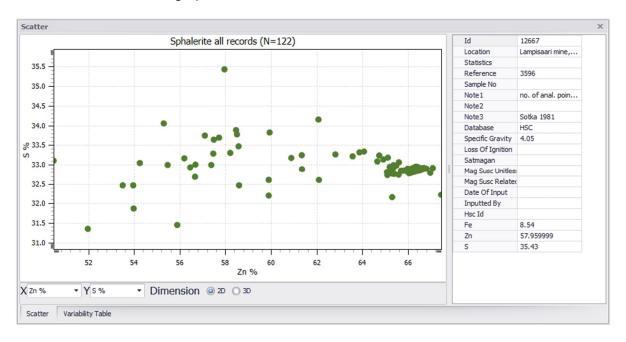


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In the scatter plot, you can change the elements shown on the X and Y axis from the combo boxes below the graph.



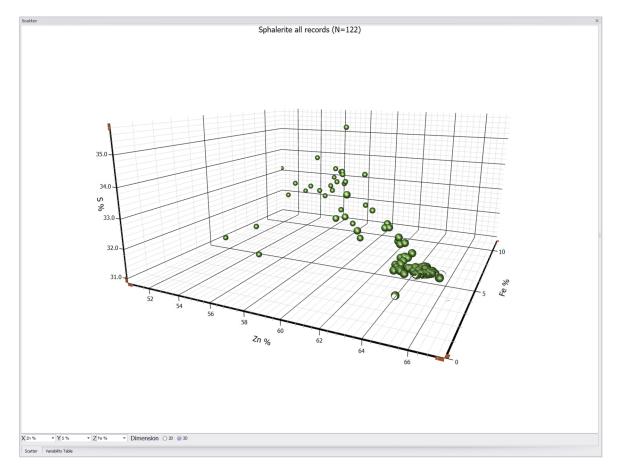
When double-clicking any of the points on the graph, the table on the right-hand side of the graph will be updated to show the mineral analysis in question.

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Id	13300
Location	Thierry mine, On
Statistics	
Reference	3619
Sample No	
Note1	
Note2	
Note3	8/table2
Database	HSC
Specific Gravity	4.05
Loss Of Ignition	
Satmagan	
Mag Susc Unitles:	
Mag Susc Related	
Date Of Input	
Inputted By	
Hsc Id	
Fe	6.22
Cu	1.5
Ni	0.15
Co	0.12
Zn	59.900002
S	32.200001

Metso

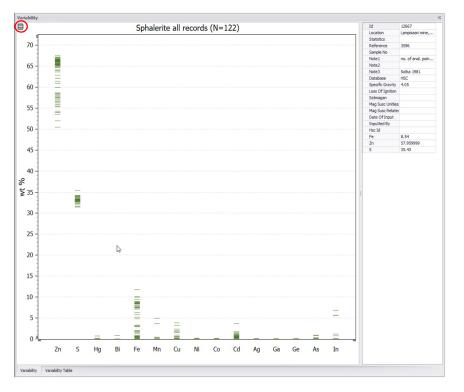
Additionally, an additional Z-axis could also be made for making 3D scatter plot.



The variability chart summarizes the variation in the chemical composition of the selected minerals in a line chart, where each analyzed element is shown on the X axis and the narrow horizontal line represents one record in the database. More information on each point can be received when double-clicking: a table on the right-hand side will show the properties of the selected mineral analysis (i.e. the content of the record (row) in the database).

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To save, copy, or print, select the three rows icon in the top left corner of the chart.

-	M/5		
E	Η	Save Chart	N
	þ	Сору	13×
	۵	Print	
		Clone	
	63	Refresh	
	A	Drawing Toolbar	
		Table Values	
	5	Format Chart	
	*	Crosshair	

You can also use a filter by pressing "Filter" in the lower left corner of the List of Minerals window. In the Filter window, you can filter the minerals by the elements found in the formula (see the previous chapter on Find mineral). Move the desired

minerals to the selected ones with the and the buttons (move selected, move all, respectively). When ready, press "Accept".

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Select Minera	Is																Anilite			
																	Bornite			
н															He		Chalco Chalco			
Li Be										В	С	N	0	F	Ne	_	Covelli			
Na Mg	_									A1	Si	D	s	CI	Ar		Cubani			
	_					_	_				31					-	Digenit			
КСа	Sc	Ti		or Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		Djurlei			
Rb Sr	Y	Zr	Nb	TC TC	Ru	Rh	Pd	Aq	Cd	In	Sn	Sb	Те	I	Xe		Fukuch			
Cs Ba		Hf	Ta	N Re	Os	Ir.	Ir.	Au	Ha	П	Pb	Bi	Po	At	Rn		Haycoc			
Fr Ra																	Idaite	auco		
		La	Ce	Pr Nd	Pm	Sm	Eu	Gd	Tb	Dv	Но	Er	Tm	Yb	Lu		Isocub			
		Ac	Th	Pa U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	1			Mooiho			
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1000000000													2		9	1	Spionk			
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ag a column he	ader here to	s group by that	column												÷					
	ader here to Symbol	group by that		pirical Formul	Group	Symbol Ref	Note			Compos	sition		/		2î					
Name				pirical Formul	a Group	Symbol Ref HSC(B1)	Note				sition 181; Cu=77	.619;	/		-1					
ag a column he Name Anilite Bornite	Symbol	Formula		pirical Formul	Group		Note			S=22.3			3.313;		21					
Name Anilite Bornite	Symbol Ani	Formula Cu7S4		pirical Formul	9 Group	HSC(B1)	Note			S=22.3 S=25.5	81; Cu=77	.128; Cu=6	3.313;				,			
Name Anilite	Symbol Ani Bn	Formula Cu7S4 Cu5FeS4		pirical Formul	Group	HSC(B1) IMA	Note			S=22.3 S=25.5 S=20.1	81; Cu=77 59; Fe=11.	.128; Cu=6 .853;								
Name Anilite Bornite Chalcocite Chalcopyrite	Symbol Ani Bn Cc	Formula Cu7S4 Cu5FeS4 Cu2S		pirical Formul	Group	HSC(B1) IMA IMA	Note (Covelline)			S=22.3 S=25.5 S=20.1 S=34.9	81; Cu=77 59; Fe=11. 47; Cu=79	.128; Cu=6 .853; .429; Cu=3								
Name Anilite Bornite Chalcocite Chalcopyrite Covellite	Symbol Ani Bn Cc Ccp	Formula Cu7S4 Cu5FeS4 Cu2S CuFeS2		pirical Formul	Group	HSC(B1) IMA IMA IMA				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30.	.128; Cu=6 .853; .429; Cu=3 .462;	4.626;			Þ				
Name Anilite Bornite Chalcocite Chalcopyrite Covellite Cubanite	Symbol Ani Bn Cc Cc Ccp Cv	Formula Cu7S4 Cu5FeS4 Cu2S CuFeS2 CuS		pirical Formul	Group	HSC(B1) IMA IMA IMA IMA				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66	.128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2	4.626;							
Name Anilite Bornite Chalcocite Chalcopyrite Covellite Cubanite Digenite	Symbol Ani Bn Cc Cc Ccp Cv Cv Cub	Formula Cu7S4 Cu5FeS4 Cu2S CuFeS2 CuFeS2 CuS CuFe2S3		pirical Formul	Group	HSC(B1) IMA IMA IMA IMA HSC(B1)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41.	.128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104;	4.626;			Þ				
Name Anilite Bornite Chalcocite Chalcopyrite Covellite Cubanite Digenite Djurleite	Symbol Ani Bn Cc Cc Ccp Cv Cv Cub Dg	Formula Cu7S4 Cu5FeS4 Cu2S CuFeS2 CuS CuFe2S3 Cu9S5	Em	pirical Formul 3FeS8	3 Group	HSC(B1) IMA IMA IMA IMA HSC(B1) IMA				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8 S=20.6	81; Cu=77. 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78	.128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337;	4.626; 3.411;							
Name Anilite Bornite Chalcocite Chalcopyrite Covellite Cubanite Digenite Djurleite Fukuchilite	Symbol Ani Bn Cc Ccp Cv Cv Cub Dg Dju	Formula Cu7S4 Cu5FeS4 Cu2S CuFeS2 CuFeS2 CuS CuFe2S3 Cu9S5 Cu31516	Em		3 Group	HSC(81) IMA IMA IMA IMA HSC(81) IMA HSC(81)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8 S=20.6 S=50.9	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 63; Cu=79	128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3	4.626; 3.411;							
Name Anilite Bornite Chalcocite Chalcopyrite Covellite Cubanite Digenite Digenite Fukuchilite Geerite	Symbol Ani Bn Cc Ccp Cv Cv Cub Dg Dju Fu	Formula Cu754 Cu5FeS4 Cu25 CuFe52 Cu5 CuFe2S3 Cu955 Cu31516 Cu3FeS8	Em		Group	HSC(81) IMA IMA IMA IMA HSC(81) IMA HSC(81) HSC(82)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8 S=20.6 S=50.9 S=23.9	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 63; Cu=79 98; Fe=11.	.128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024;	4.626; 3.411; 7.899;			N	li			
Name Anilite Bornite Chalcocite Chalcocyrite Covellite Cubanite Digenite Djurleite Fukuchilite Geerite Haycockite	Symbol Ani Bn Cc Ccp Cv Cub Dg Dju Fu Gee	Formula Cu754 Cu5FeS4 Cu25 CuFeS2 CuFeS2 CuFe2S3 Cu955 Cu31516 Cu3FeS8 Cu855	Em		3 Group	HSC(81) IMA IMA IMA IMA HSC(81) IMA HSC(81) HSC(82) HSC(81)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8 S=20.6 S=50.9 S=23.9 S=23.9 S=32.4	81; Cu=77 559; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 63; Cu=79 98; Fe=11. 76; Cu=76	.128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024; .348; Cu=3	4.626; 3.411; 7.899; 2.178;			DI D				
Name Anilite Bornite Chalcooite Chalcoopyrite Covellite Cubanite Digenite Digenite Digurleite Fukuchilite Geerite Haycockite Idaite	Symbol Ani Bn Cc Cc Ccp Cv Cub Dg Dju Fu Gee Hay	Formula Cu754 Cu254 Cu25 CuFe52 Cu5 CuFe253 Cu955 Cu31516 Cu31e58 Cu855 Cu4Fe558	Em		3 Group	HSC(81) IMA IMA IMA IMA HSC(81) HSC(81) HSC(82) HSC(81)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=20.6 S=50.9 S=23.9 S=23.9 S=32.4 S=34.2	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 63; Cu=79 98; Fe=11. 76; Cu=76 74; Fe=35.	128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024; .348; Cu=3 .902; Cu=5	4.626; 3.411; 7.899; 2.178; 0.871;			N				
Name Anilite Bornite Chalcocite Chalcopyrite Covellite Covellite Digenite Digenite Digenite Fukuchilite Geerite Haycockite Idaite Isocubanite	Symbol Ani Bn Cc Cc Cc Cv Cv Cub Dg Dju Fu Gee Hay Ida	Formula Cu754 Cu5FeS4 Cu25 CuFeS2 Cu5 Cu7e2S3 Cu955 Cu31516 Cu3FeS8 Cu855 Cu4FeS58 Cu4Fe558 Cu3FeS4	Em		Group	HSC(81) IMA IMA IMA HSC(81) IMA HSC(81) HSC(81) HSC(81) HSC(81) HSC(81)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8 S=20.6 S=50.9 S=23.9 S=23.9 S=32.4 S=34.2 S=35.4	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 663; Cu=79 98; Fe=11. 76; Cu=76 74; Fe=35. 227; Fe=14.	128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024; .348; Cu=3 .902; Cu=5 .148; Cu=2	4.626; 3.411; 7.899; 2.178; 0.871; 3.411;			DI D				
Name Anilite Bornite Chalcocite	Symbol Ani Bn Cc Ccp Cv Cub Dg Dju Dju Fu Gee Hay Ida Iso	Formula Cu754 Cu5Fe54 Cu25 Cu7e52 Cu5 Cu7e253 Cu955 Cu31516 Cu3Fe58 Cu3Fe58 Cu3Fe558 Cu3Fe558 Cu3Fe558 Cu3Fe54 CuFe253	Em		Group	HSC(81) IMA IMA IMA IMA HSC(81) IMA HSC(81) HSC(81) HSC(81) HSC(81) HSC(81)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8 S=20.6 S=50.9 S=23.9 S=23.9 S=32.4 S=34.2 S=35.4	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 863; Cu=79 98; Fe=11. 76; Cu=76 74; Fe=35. 27; Fe=14. 41; Fe=41.	128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024; .348; Cu=3 .902; Cu=5 .148; Cu=2	4.626; 3.411; 7.899; 2.178; 0.871; 3.411;			DI D				
Name Anilite Bornite Chalcoorite Covellite Cubanite Digenite Djurleite Fukuchilite Geerite Haycockite Idaite Isocubanite Mooihoekite	Symbol Ani Bn Cc Ccp Cv Cub Dg Dju Fu Gee Hay Ida Iso	Formula Cu754 Cu5FeS4 Cu5FeS4 CuFeS2 CuFe2S3 Cu9FeS5 Cu3FeS8 Cu3FeS8 Cu3FeS4 Cu3FeS4 Cu5FeS3 Cu5FeS3 Cu5FeS3 Cu5FeS3 Cu5FeS3 Cu5FeS3 Cu5FeS3	Em		Group	HSC(81) IMA IMA IMA HSC(81) IMA HSC(81) HSC(81) HSC(81) HSC(81) HSC(81) HSC(81)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=21.8 S=20.6 S=50.9 S=23.9 S=32.4 S=32.4 S=35.4 S=35.4 S=32.3	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 863; Cu=79 98; Fe=11. 76; Cu=76 74; Fe=35. 27; Fe=14. 41; Fe=41.	128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024; .348; Cu=3 .902; Cu=5 .148; Cu=2	4.626; 3.411; 7.899; 2.178; 0.871; 3.411;			DI D				
Name Anilite Bornite Chalcopyrite Covellite Cubanite Digenite Digenite Digenite Haycockite Haycockite Idate Isocubanite Nucuhamite	Symbol Ani Bn Cc Ccp Cv Cu Dg Dg Dju Fu Gee Hay Ida Iso Moo Nuk	Formula Cu754 Cu5Fe54 Cu25 CuFe52 Cu555 Cu355 Cu355 Cu3555 Cu3555 Cu35558 Cu37e58 Cu37e58 Cu37e58 Cu37e558 Cu37e558 Cu37e558 Cu37e558 Cu37e558 Cu37e558 Cu37e558 Cu37e558	Em		3 Group	HSC(B1) IMA IMA IMA HSC(B1) IMA HSC(B1) HSC(B1) HSC(B1) HSC(B1) HSC(B1) HSC(B1) HSC(B1)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=20.6 S=50.9 S=23.9 S=23.9 S=23.4 S=34.2 S=35.4 S=32.3 S=21.8	81; Cu=77 59; Fe=11. 47; Cu=79 45; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 663; Cu=79 998; Fe=11. 76; Cu=76 74; Fe=35. 27; Fe=14. 41; Fe=41. 17; Fe=31.	128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024; .348; Cu=3 .902; Cu=5 .148; Cu=2 .659; Cu=3 .104;	4.626; 3.411; 7.899; 2.178; 0.871; 3.411;			DI D				
Name Anilite Bornite Chalcocite Covelite Covelite Covelite Covelite Digenite Digenite Digenite Digenite Fukuchilite Geerte Haycockite Isocubanite Mooihoekite Nukundamite Roxbyte	Symbol Ani Bn Cc Cc Cv Cv Cv Cub Dg Dju Dju Fu Gee Hay Ida Iso Moo Nuk Rox	Formula Cu754 Cu5Fe54 Cu2Es2 CuFe32 Cu955 Cu31516 Cu3Fe58 Cu4Fe558 Cu3Fe34 Cu4Fe558 Cu3Fe3516 Cu3Fe354 Cu4Fe558	Em		3 Group	HSC(81) IMA IMA IMA IMA IMA HSC(81) HSC(81) HSC(81) HSC(81) HSC(81) HSC(81) HSC(81) HSC(81) HSC(81)				S=22.3 S=25.5 S=20.1 S=34.9 S=33.5 S=35.4 S=20.6 S=50.9 S=23.9 S=23.9 S=32.4 S=32.4 S=35.4 S=32.3 S=21.8 S=21.8 S=21.8	81; Cu=77 59; Fe=11. 47; Cu=79 445; Fe=30. 38; Cu=66 41; Fe=41. 96; Cu=78 96; Cu=78 98; Fe=11. 76; Cu=76 74; Fe=35. 27; Fe=44. 41; Fe=41. 17; Fe=31. 99; Cu=78	128; Cu=6 .853; .429; Cu=3 .462; .148; Cu=2 .104; .337; .102; Cu=3 .024; .348; Cu=3 .902; Cu=5 .148; Cu=2 .659; Cu=3 .104; .406;	4.626; 3.411; 7.899; 2.178; 0.871; 3.411;			DI D				

In the List of Minerals window, select the mineral that you want to study further.

84.5. Find by Composition

"Find by Composition" is used to find a name for a mineral based on its chemical composition. Typically, this kind of question is faced when studying samples with scanning electron microscope (SEM) and EDS (or WDS) and an analysis is collected from a mineral grain.

Press "Find by Composition" in the left panel.

Mine	ral Database	^
	Catalogue Find by Properties <u>Find by Composition</u> Database View	
Calc	ulations	^
20	Modal Mineral Liberation Petrological	

Let us propose that the EDS analysis gave 26% Cu, 22% Sb, 27% S, 5% Fe, and 20%

Ag. To start with, press the Add button and select Cu for the element, % for the proportion, 26 for the value. SD is a standard deviation and you can obtain this information by analyzing the same grain several times and calculating the value of the standard deviation. You can use a default value of 1%. Press OK and add the next elements. Alternatively, the elements can be added by choosing from the periodic table

Periodic	Table

dd New Value				3
	Select e	lement, its value ar	id SD	
Element	Proportion	Value	SD	ОК
Cu 🔹	% ▼	26 🗅	1:	Cancel

Finally, when you have added all the conditions to be identified, press

Find	

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on	npositio	n			R	esults								
E	lement	Proportion	Value	SD		WSSQ	Mineral Name	Location	Mineral Key	Reference	Note 1	Note 3	Database	Fe %
• 0	Du	% •	26	1	•	39.252011	Tetrahedrite	Lampisaari mine, Vihanti	Sotka 1981	3596	no. of anal	Sotka 1981	HSC	3.5
5	sb	%	22	1		60.925896	Tetrahedrite	Lampisaari mine, Vihanti	Sotka 1981	3596	no. of anal	Sotka 1981	HSC	6.3
5	5	%	27	1		67.865690	Tetrahedrite	Lampisaari mine, Vihanti	Sotka 1981	3596	no. of anal	Sotka 1981	HSC	3.86
F	e	%	5	1		119.49620	Tetrahedrite	Lampisaari mine, Vihanti	Sotka 1981	3596	no. of anal	Sotka 1981	HSC	3
1	Ag	%	20	1		383.97480	Tetrahedrite	Spain	4/Table2	3615	Vein	4/Table2	HSC	2.01
						405.40399	Tetrahedrite	Spain	3/Table2	3615	Vein	3/Table2	HSC	2.11
						429.38988	Tetrahedrite	Spain	5/table2	3615	Vein	5/table2	HSC	2.11
						439.08870	Tetrahedrite	Spain	9/Table2	3615	Altered Zone	9/Table2	HSC	0.79
						440.87842	Tetrahedrite	Spain	10/Table2	3615	Altered Zone	10/Table2	HSC	2.5
						455.51540	Tetrahedrite	Suurikuusikko	Kojonen & Jo		Trace condi	Kojonen &	HSC	3.68858

Geo will show you the 10 best matching minerals. Matching is done by calculating the Weighed Sum of Squares according to the following function:

$$WSSQ = \sum_{E=1}^{n} \left(\frac{Database_{E} - Given_{E}}{SD_{E}} \right)^{2}$$

The lower the WSSQ, the better the match. The rows are displayed in the order of increasing WSSQ. This time all the 10 best matches are for tetrahedrite and the identification can be regarded as reliable.

The table can be organized by right-clicking on the columns and for example hiding it (Hide This Column).



The number of minerals listed can be changed in the lower part of the window.

10 🌲	Number of minerals listed	
------	---------------------------	--

It is also possible to change the given assays (composition) to oxide form.

84.6. Petrological calculations

84.6.1. General procedure

The general procedure of HSC Geo in working with rock and mineral analyses is as follows:

- 1) Prepare the data e.g. in Excel and save using Excel file format.
- 2) Open the files in HSC Geo or paste to HSC Geo
- 3) Run the identification routine
- 4) Customize the calculation routines, if required
- 5) Do the calculations
- 6) Check and recalculate, if necessary
- 7) Save the result

84.6.2. Preparing the data

To ease and quicken the data processing in HSC Geo, prepare your data to satisfy the following requirements:

- Data should be row-wise; one observation or measurement per line, i.e. each sample has its own row.
- Place each data type in its own file or own sheet. For example, one sheet/file has the header information of samples, one sheet includes XRF analyses, another REE analyses, and one PGE assays
- Place the header in the first row and ID column in the first column
- In the header row or rows you should specify the element in analysis, the analysis method, and the unit, e.g. SiO2/XRF/%. The following options exist:
 - o Place the element, method and unit in individual rows:
 - Place the element in the first row and name this row ELEMENT
 - Place the method in the second (or third) row and name it METHOD
 - Place the unit in its own row and name it UNIT. HSC Geo understands the following units: wt%, %, ppm, g/t, ppb
 - Place the element, method and unit in the first row and separate them with a space or / (e.g. Cr XRF ppm, Cr/XRF/ppm)
 - Name the file or sheet according to the method and then there is no need to repeat it. On the XRF sheet, the header gives the element and method, for example, Cr ppm.
- The decimal separator should be a point (e.g. 21.34)
- Save data as an Excel file (version 5) or as a tab-separated text file

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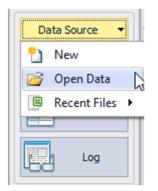
84.6.3. Tutorial Data in Excel File with Multiple Sheets – Step-by-step

This tutorial guides you through the HSC Geo steps where you open the dataset, perform the calculations, and save the result in the database.

1. Run HSC Geo, Choose Petrological

Geo 1	Tools	
Mine	ral Database	^
\$	Catalogue	
Q,	Find by Properties	
	Find by Composition	
3	Database Viewer	
Calc	ulations	^
J at	Modal	
20	Mineral Liberation	
	Petrological	

2. Select Data Source, then Open Data from the left button list



- 3. Select from the data folder (C:\Program Files (x86)\HSC10\Geo\Data) example file Bruvann.xls
- 4. HSC Geo opens the Excel file and places each sheet as its own source window. A total of seven sources are visible:
 - Bruvann / Header (header data, location data)
 - Bruvann / LOI (loss of ignition analyses)
 - Bruvann / LECO (Leco analyses)
 - Bruvann / BM (bromine-methanol analyses)
 - Bruvann / XRF (X-ray fluorescence analyses)
 - Bruvann / PGE (PGE analyses)
 - Bruvann / REE (REE analyses)

In each source (Excel sheet) the data is row-wise, the first row includes the header, and the sample ID is placed in each file in the first column. For the chemical elements, both the element name and unit are given in the first row separated by a space, e.g. Al2O3 %. Each source (i.e. Excel sheet) has been named according to the assay method. Please follow this procedure with your own data. Do not leave empty columns or rows.

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Petrological Calculations	Bruvann.xls -	Header	Bruva	nn.xls - REE	Bruvann.)	ds - PGE	Bruvann.xls	- XRF	Bruvann.xls - BM	Bruvann	n.xls - LECO	Bruvann.	xls-LOI 🗶	
Parameters	д		А	В	С	D	E	F	G	н	1	J	К	L
				SampleNo	LOI %									
Identified	lentifv		ELEMENT	-	LOI									
Identified			METHOD		LOI									
Hide system rows			UNIT		%									
Advanced settings			TABLE											
			FIELD											
			TYPE	LONG(U,I)	SINGLE									
			LENGTH											
			DIGITS	VEO										
			INDEXED MULTIPLI											
			IDENTIFIE		X(LOI)1/1									
		13		9619410	0.01									
		14		9619411	0.23									
		15		9619412	0.28									
		16		9619413	0.47									
		17		9619414	0.07									
		18		9619415	0.75									
		19		9619416	0.94									
		20		9619417	0.29									
		21		9619418	0.48									
		22		9619428	0.13									
		23		9619430	0.07									
		24		9619453	4.0500002									
		25		9619459	1.74									

5. If the excel data fulfil the format requirements, HSC Geo would automatically identify the structure when opening the data. Otherwise, click identify in the Parameters window. If identified correctly the status would turn from red dot "Not Identified" to green dot "Identified"

Parameters	ц.
Identified Identify	
Hide system rows	
Advanced settings	

- 6. HSC Geo identifies the structure of each source and, to indicate the result, each source includes **header rows** (blue text on gray background) as follows:
 - -Hdr- HEADER: is the original header of the data
 - -Ele- ELEMENT: is the name of the chemical element if HSC Geo has identified the column as a chemical element
 - · -Met- METHOD: indicates the method of the analysis (e.g. XRF)
 - -Uni- UNIT: unit of the assay (e.g. ppm)
 - Tab- TABLE: name of the table where the data will be stored, for analysis ANALYSIS is default
 - -FId- FIELD: name of the field in the table, e.g. SiO2/XRF/% in the table ANALYSIS
 - -Typ- TYPE: field type, e.g. SINGLE
 - -Len- LENGTH: length of the character field
 - · -Dig- DIGITS: number of digits in the numeric fields
 - -Idx- INDEXED: Yes, if the field is indexed. Key and ID fields are indexed
 - -Mul- MULTIPLIER: The multiplier if the data has been multiplied to reach a uniform structure, e.g. Fe-> FeO
 - -Idf- IDENTIFIED: X and name of the chemical element and the total number of the element in the source, e.g. X(Si)1/2 indicates that the field is silica and there are also silica analyses with possible different analysis methods in the same file

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Parameters	Д.		A	В	С	D	E	F	
		1	HEADER	SampleNo	SiO2 %	TiO2 %	AI2O3 %	Cr2O3 %	V20
	Identify	2	ELEMENT		SiO2	TiO2	AI2O3	Cr2O3	V20
Identified		3	METHOD		XRF	XRF	XRF	XRF	XRF
Hide system rows		4	UNIT		%	%	%	%	%
		5	TABLE		ANALYSE	ANALYSES	ANALYSES	ANALYSE	ANA
Advanced settings		6	FIELD	SampleNo	SiO2/XRF/	TiO2/XRF/	AI2O3/XRF	Cr2O3/XRF	V20
		7	TYPE	LONG(U,I)	SINGLE	SINGLE	SINGLE	SINGLE	SING
		8	LENGTH						
		9	DIGITS						
		10	INDEXED	YES					
\searrow		11	MULTIPLIE	R					
-0		12	IDENTIFIE	ID	X(Si)1/1	X(Ti)1/1	X(AI)1/1	X(Cr)1/1	X(V):
		13		9619251	53.200001	0.69	17.799999	0.0226	0.03
		14		9619256	47	0.725	12.1	0.143	0.02
		15		9619257	45.5	0.603	11.2	0.184	0.02
		16		9619258	52.700001	0.547	13.1	0.216	0.04

7. In the calculation window you can define settings to include:

Metso

- Data source (check the sources you want to use) (1)
- Priority order for methods for each element (2)
- Calculation group selected (3)
- Calculations to be performed (4)

	1				2	2						_
Petrological Calculations		Bruvann.xls - REE	Bruvann.xls - PGE	Bruvann.xls	- XRF	Bruvann.xls - BM	Bruvann.>	ls - LECO	Bru	vann.xls	- LOI	
Data Source *	Data Source Bruvann.xls - Header Bruvann.xls - REE	Method Priority Sett	ings 2 3 4	5	6 7	8 9						
Settings	Bruvann.xls - PGE Bruvann.xls - XRF	H Li Be					8		N	0	F	He
Result	Bruvann.xls - BM	Na Mg					AL	s	P	s	a	Ar
	Bruvann.xls - LOI	K Ca Sc	Ti V C	Mn	Fe	o N Cu	Zn Ga	Ge	As	Se	Br	Kr
63		Rb Sr Y Cs Ba	Zr ND N Hr Ta V	No Tc V Re	Ru R Os I	n Pd Ag	Cd In Hg Ti	Si Pb	Sb Bi	Te Po	I At	Xe Rn
Calculations		Fr Ra	La Ce P	* Nd	Pm	m Eu Gd	Тв Dy	Но	Đ	Tm	Yb	Lu
Calculate	100000		Ac Th P	u U	Np	u Am Cm	Bk Cr	Б				
3	Calculations ROCK	General Method Pri Bruvann.xls - REE [F	REE]	⊠ Тор	Bruvann	Priority for [All element	<u>s]</u> in <u>[All calcu</u>	lations]			Z	Тор
	check All 🕵	Bruvann.xls - PGE [F Bruvann.xls - XRF [) Bruvann.xls - BM [BI	(RF]	⇔ Up ⊽ Down	Bruvann							
4	time	Bruvann.xls - LECO Bruvann.xls - LOI [L	[LECO]	▽ Down☑ Bottom	Bruvann						P N	Down Bottom
	CATION CIPW										-	Reset
	CUMNAME LEMENT OXIDE REE_N SF TRACE_N TRC VF VSF											
	Manage calculations	Show method priority	<u>y list for</u>		Edit meth	nod priority exclusions fo	<u>or</u>					

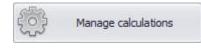


In order to edit the priority order (the order of methods used in calculations):

• Click the element of interest, the color code shows where the data sources (methods) of the element can be found. For example, in the figure below, cobalt can be found in two data sources: [BM] and [XRF]. Use the Top, Up, Down, and Bottom buttons to move the methods in the desired order.

Method Priority Set	ttings														
0	2	З	4		5	6	7	8							
н															He
U Be										8	с	N	0	F	Ne
Na Mg										Až	s	P	5	a	Ar
K Ca Sc	Ti	V	Gr	Ma	Fe	Co	н	Cu	Zn	Ga	Ge	As	8	Br	Kr
RD Sr Y	2	ND	No	Te	Ru	Rh	90	Ag	Cd	In	Sn	9	Те	I	Xe
Cs Ba	н	Ta	W	Re	Os	ţ.	R	Au	Hg	TI	PD	8	Po	At	Rn
Fr Ra	1.01	G	Pt	No	Pm	Sm	Eu	Gd	то	Dy	нь	Đ	Tm	Yb	Lu
	Ac	Th	Pa	U	Np	Pu	Am	Cm	BK	C	5]			
General Method P	riority			Meth	nod Prior	rity for	<u>Co]</u> in [All calcul	ations]						
Bruvann.xls - BM [B		⊠ 1	ор		สมารณ์ระ									Z	Тор
Bruvann.xls - XRF Bruvann.xls - LECC		4	Up	Bruva											Up
Bruvann.xls - PGE Bruvann.xls - REE		⊽ D	own											0	Down
bruvann, xis - REE j	REEJ	⊠ Bo	ttom											¥	Bottom
															Reset
Show method priori	ty list for				nethod n										
				Ind Tesler	sritada Ti	Conneral	Mathad	Deineitul							

 The calculation options can be edited by pressing "Manage Calculation."



and by selecting the appropriate method. For more details on calculation routines and how to modify them, see the following chapters.

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1anage Calculation Routines	
Rename Attach Delete Delete	Rename Save changes Save changes Save changes Save as alculation Routines A
ANION ARRANGE ATOMIC CATION CLIPW CUMNAME ELEMENT OXIDE REE_N SF TRACE_N TRC VF VSF	A B C D E F G H I J K A 1 This is SF routine of the HSC Geo Data is brought to the Input -sheet (required) Selection is made on the Calc -sheet Result is read from the Output -sheet (required) Selection is made on the Calc -sheet Result is read from the Output -sheet (required) For the Calculation chemical composition of sulfide phase. Pertit Lamberg 9.5.2006; pertit lamberg@outotolec.com Pertit Lamberg 9.5.2006; pertit lamberg@outotolec.com Selection is notice calculates the mineral and chemical composition of sulfide in fraction sulfides recalculated to 100% Following minerals are calculated 10 This routine calculates the mineral and chemical composition of sulfide in fraction sulfides recalculated to 100% Following minerals are calculated 12 Following minerals are calculated Cpp Chalcopyrite Following minerals Followi

9. When the identification is ready, you can progress to calculations. Check the calculations you want to do for the samples by checking and unchecking the calculations in the list box. The calculations listed below are done by default. When ready, press "CALCULATE"

00	Settings
	Result
B	Log
Calcula	tions
	Calculate

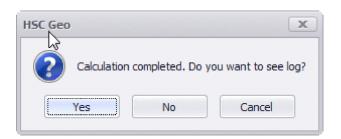
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etrological Calculations	×	Bruvann.xls	- Header B	ruvann.xls - REE	Bruvann.xls	- PGE	Bruva	ann.xls - XRF	Bruvann.xls - BN	1 Bruvann.	ds - LECO E	Bruvann.xls - LOI	
Data Source +		А	В	С	D	E		F	G	н	1	J	К
Data Source +	1	ID	Ccp SF %	Cpn SF %	Pn SF %	MIb SF %	6	Apy SF %	Sp SF %	Gn SF %	Po SF %	Cu SF %	Co SF %
Settings	2	9619251	1.51581763	5.958672615	1.955372997		0	1.140725243	5.475982884	1.212184773	82.21637669	0.524867166	3.67407
	3	9619256	3.389014067	1.18948206	15.57438419		0	0.159399695	0.765188645	0	78.84918883	1.173480353	0.73342
	4	9619257	3.734591902	1.398158573	26.33591584		0	0.187363944	0.89942934	0	67.35833105	1.293140169	0.86209
Result	5	9619258	1.032716514	1.449858563	9.325278564		0	0.388584277	1.598893197	0.206463364	85.81941126	0.357588524	0.8939
	6	9619259	0.527579354	1.481365766	2.041698874		0	0.794057379	1.633639105	0.210950066	93.12802978	0.18267968	0.9133
Log	7	9619260	1.842909261	1.552386054	5.348956806		0	0.693438668	1.188860863	0	89.21391686	0.638125947	0.9571
	8	9619261	4.430760463	1.610002489	30.59520517		0	0.392277538	1.210567228	0	61.67094032	1.534195566	0.9927
Calculations	9	9619262	3.897665927	2.188815475	46.16533359		0	0.799958185	1.462914796	0.141678459	45.22094209	1.349606198	1.3496
Calculate	10	9619263	4.848683729	2.995167311	55.66683634		0	0.729773319	2.001847404	0.193872299	33.39592901	1.678905718	1.8467
Calculate	11	9619264	4.383529108	3.938659575	57.67753981		0	0.659763095	2.262252047	0.350546629	30.1205732	1.517841232	2.4285
	12	9619265	4.932496362	3.046940714	50.26625778		0	0.742387922	2.036450631	0.197223507	38.6074504	1.707926689	1.8787
	13	9619266	5.431412777	3.355135313	60.25511848		0	2.861178619	2.242435303	0.217172442	25.4494789	1.880681537	2.0687
	14	9619267	5.91129306	2.845379703	42.48461752		0	0.317752196	1.743257508	0.337657447	46.21383936	2.046844932	1.7544
	15	9619268	4.19529173	2.355953443	39.68681489		0	0.789289405	1.623829781	0.13978894	51.08797663	1.452662138	1.4526
	16	9619269	4.545765062	2.340038255	39.58160644		0	0.285075474	1.759484003	0.151466863	51.20539581	1.574017069	1.442
	17	9619270	2.665039438	0.621233679	8.691910471		0	0.037840938	0.207603599	0.020105722	87.75626615	0.922796825	0.3830
	18	9619271	2.558609352	2.586312608	11.88198868		0	0.385095201	1.584536828	0.204609542	80.79884779	0.885944333	1.5946
	19	9619272	3.397052715	1.335380061	10.07889201					0.135829528	83.51005765	1.176263816	0.8233
	20	9619273	2.175653862	1.069060752	4.209821711		0	0.202560445	0.42105434	0	91.91974889	0.753342126	0.6591
	21	9619274	4.313966875	4.239546327	34.78079212		0	0.405808292	2.226352364	0.215614862	53.63119983	1.493754606	2.6140
	22	9619275	5.526241675	3.667626399				2.268415172		0.200876478	50.05623734	1.913517001	2.2614
	23	9619276	0		0		0	0	0	0	99.7080051	0	
	24	9619277		1.882834882			0	0.58226367	1.064808328	0	32.55988792	2.053972499	1.1
	25	9619278	4.59756972	2.237612986	32.02615154		0	0.922637676	1.107266659	0.122554417	58.986207	1.591954956	1.3796
	26	9619279	0	-	0		0	0	0		99.54914597	0	
	27			1.010471466					0.422098611			1.812505295	
	28	9619281	4.874372043	0.807154063	30.39121598							1.687800556	
	29	9619283	1.848189754	1.55683409	12.31798442		0	0.695425579	1.112782924	0.123164968	82.2389592	0.639954371	0.9599



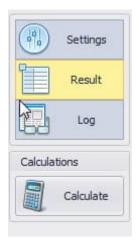
10. When completed, Geo asks if you want to see the log.



11. If there are errors you can see them in the Log window.

	3) Messages (2	2) Warnings	(0) Errors	
	Calculation	Sample	Me	essage
•			Lo	ad calculation settings
	[CUMNAME]		Ca	lculation order has been changed to meet calculation requirements
	[VSF]		Ca	lculation order has been changed to meet calculation requirements
			Ca	lculations started
			Ca	lculations completed

12. Calculation results are calculated in the "Calculation Result" window,



which is similar in structure to the input files. The result of each of the calculation routines is shown on its own page.

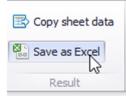
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	A	В	С	D	E	F	G	н	1	J	K	L	M	N	
L	ID	H2O %	Li20 %	CO2 %	Na2O %	MgO %	AI2O3 %	SiO2 %	P2O5 %	K2O %	CaO %	TiO2 %	V2O3 %	Cr2O3 %	N
2	9619251			0.439992007	3.039999937	7.53000021	17.79999877	53.20000076	0.133000006	0.579999983	9.989857543	0.689809539	0.038199998	0.022600014	10
3	9619256			0.729986762	1.649999963	18.89999962	12.10000006	47	0.141000008	1.09000033	5.159926384	0.724799904	0.022299999	0.143000094	i C
F.	9619257			0.549990024	1.690000043	21.79999924	11.19999952	45.5	0.150000011	0.5	5.299924735	0.602833541	0.022299999	0.184000112	1
5	9619258			0.549990024	1.619999992	15.30000019	13.10000004	52.70000076	0.102000002	0.519999981	6.369909196	0.546849004	0.047800001	0.216000137	1
5	9619259			1.199978255	1.08000034	15.19999981	12.79999986	51	0.035000001	0.449999988	7.899887623	0.378895394	0.056400001	0.197000117	1 (
'	9619260			0.509990729	1.480000007	15.5	13.19999946	50.90000153	0.054000003	0.360000014	7.139898214	0.391891787	0.0504	0.170000105	i 1
3	9619261			0.589989259	1.87999998	20	11.19999952	47.59999847	0.076	0.419999987	4.779932157	0.482866689	0.0287	0.08740005	; (
9	9619262			0.549990024	1.039999954	26.39999962	7.899999888	43.40000153	0.088000003	0.340000004	3.989943204	0.518856736	0.0187	0.10500006	; (
0	9619263			0.479991272	1.24999999	26.5	8.699999581	44.40000153	0.078000004	0.46000008	4.289938885	0.460872747	0.016799999	0.106000063	1
1	9619264			0.439992007	2.180000049	17.70000076	15.49999959	47.09999847	0.081000003	0.670000017	6.889901773	0.408887114	0.017000001	0.103000063	1
2	9619265			0.509990729	1.190000047	27	8.799999961	43.90000153	0.059000003	0.370000005	4.479936237	0.303916078	0.0147	0.118000072	ł
3	9619266			0.509990729	1.059999934	28	7.799999987	42.59999847	0.077000002	0.360000014	4.299938972	0.323910568	0.0177	0.299000177	1
4	9619267			0.839984719	1.029999963	27.79999924	7.999999791	43	0.050000003	0.270000011	4.50993602	0.323910568	0.0243	0.429000251	L.
5	9619268			0.769985997	1.009999982	29.29999924	7.3	42.29999924	0.053000001	0.280000001	3.679947675	0.363899519	0.024499999	0.451000279	1
6	9619269			0.549990024	1.029999963	29.39999962	7.599999706	42.29999924	0.044000001	0.289999992	3.969943508	0.332908087	0.022299999	0.38700023	i i
7	9619270			0.699987276	0.959999971	24.89999962	7.199999621	41.5	0.05000003	0.25	4.159940621	0.36489926	0.0297	0.3530002	1
8	9619271			0.509990729	1.509999978	16.89999962	12.3999993	51	0.067000004	0.469999999	6.319910194	0.617829386	0.044100001	0.282000176	i
Э	9619272			0.479991272	0.999999992	18.70000076	9.89999936	51.90000153	0.023000001	0.60000024	4.909929943	0.496862823	0.0568	0.279000184	ŧ.
0	9619273			0.439992007	1.669999943	8.680000305	22.39999903	49.79999924	0.025000001	0.259999991	10.49985051	0.246931815	0.028999999	0.112000072	ł
1	9619274			0.479991272	0.809999996	29.6000038	6.49999983	44.20000076	0.072	0.319999993	3.229954034	0.317912212	0.025699999	0.196000114	i i
2	9619275			0.589989259	0.589999969	26.5	7.199999621	46.59999847	0.045000003	0.349999994	3.329952515	0.319911664	0.035300002	0.231000146	i
3	9619276			0.439992007	0.730000013	31.79999924	4.599999785	43.79999924	0.083	0.469999999	2.88995896	0.474868881	0.024599999	0.184000112	2
4	9619277			0.32999402	0.660000021	31.89999962	5.69999966	43.5	0.046000002	0.370000005	3.229954034	0.215940384	0.0151	0.110000066	;
5	9619278			0.619988745	0.699999982	31.20000076	5.599999758	42.20000076	0.083	0.569999993	2.58996304	0.300916915	0.0119	0.068300043	i
6	9619279			0.619988745	0.699999982	32.29999924	5.199999673	42.70000076	0.065	0.349999994	2.799960088	0.361900067	0.0124	0.070600046	;
7	9619280			0.699987276	0.779999965	21.20000076	5.599999758	48.59999847	0.039000002	0.209999993	10.49985051	0.565843754	0.0524	0.183000109	ł
В	9619281			0.65998804	0.62	30.70000076	5.69999966	39.40000153	0.028000002	0.239999995	3.329952515	0.145959698	0.0154	0.073000043	1
9	9619283			0.369993285	1.289999952	13.10000038	16.99999956	52.40000153	0.104000006	0.409999996	7.599891704	0.282921877	0.043099999	0.21900013	1
0	9619284			0.369993285	0.490000006	34.70000076	3.999999895	44.40000153	0.044000001	0.46000008	1.929972471	0.236934585	0.0126	0.27200018	\$
-	P. H. FL	EMENT /	Main OX	IDE PGE REE	REE N SE TR	ACE N/TRC/Tr	ace /VE /VSE /								-

13. To save the results, press Save as Excel and give the file a name.



84.6.4. Calculation routines

Metso

HSC Geo allows you to calculate certain frequently used routines in the same way, although the input format may change from one data source to another. HSC Geo includes a number of petrological calculation routines but since the actual calculations are carried out in Microsoft Excel, it is quite easy for users to make their own routines as well.

General structure

In HSC Geo, the calculation routines are actually Microsoft Excel files. Files must be located in folders under C:\Program Files (x86)\HSC10\Geo\C-Groups. In the example below, there are two different sets of calculations: "ROCK" and "MINERAL."

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🔹 🛪 🛣 Open 💌	Print	Burn	New folder		
Name	^		Date modified	Туре	Size
퉬 MINERAL			2015-05-11 14:45	File folder	
Di ROCK			2015-05-11 14:45	File folder	
template.xls			2015-05-09 02:56	Microsoft Excel 97	38 KB

Under the ROCK folder (i.e. C:\Program Files (x86)\HSC10\Geo\C-Groups\ROCK) there are Excel files, all of which have their own individual calculation routines.

Include in library	with 🔻 🛛 Burn	New fold	ler	
Vame	Date	modified	Туре	Size
ANION.xls	2015	-05-09 02:56	Microsoft Excel 97	44 KB
ARRANGE.xls	2015	-05-09 02:56	Microsoft Excel 97	150 KB
ATOMIC.xls	2015	05+09 02:56	Microsoft Excel 97	57 KB
CATION.xls	2015	-05-09 02:56	Microsoft Excel 97	61 KB
CIPW.xls	2015	-05-09 02:56	Microsoft Excel 97	301 KB
CUMNAME.xls	2015	-05-09 02:56	Microsoft Excel 97	48 KB
ELEMENT.xls	2015	-05-09 02:56	Microsoft Excel 97	48 KB
OXIDE.xls	2015	-05-09 02:56	Microsoft Excel 97	54 KB
REE_N.xls	2015	-05-09 02:56	Microsoft Excel 97	43 KB
SF.xls	2015	-05-09 02:56	Microsoft Excel 97	49 KB
TRACE_N.xls	2015	-05+09 02:56	Microsoft Excel 97	43 KB
TRC.xls	2015	-05-09 02:56	Microsoft Excel 97	116 KB
VF.xls	2015	-05-09 02:56	Microsoft Excel 97	73 KB
VSF.xls	2015	-05-09 02:56	Microsoft Excel 97	50 KB

The calculation file consists of five worksheets.

- 1. The first worksheet (Info) is for information.
- 2. The second worksheet (Setup) gives the ordinal number of the routine and defines which routines should be done before the calculation in question is run.
- 3. The third worksheet is the Input sheet, i.e. data from HSC Geo to Excel.
- 4. The fourth worksheet (Calc) is reserved for calculations done in Excel.
- 5. The fifth worksheet (Output) is for output data, i.e. data from Excel to HSC Geo.

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File	Hom	e Inse	rt Page Layou	t Formulas	s Data	Review
	🔏 Cut		Arial	• 10 • A	A A ≡ ≡	= 📒 🗞
Paste		t Painter	B <i>I</i> <u>U</u> ∗	- 🖉 -	<u>A</u> · ≡ ∎	F 🗐 👎
	Clipboard	F2	Fo	nt	- F2	AI
	B4	•	fx fx	See Lamber	rg 2006. From	genetic co
1 2 3 4 5	5	See Lamb	B AME routin erg 2006. From g Geological Surv	enetic conce	pts to practic	
1 2 3 4 5 6 7	(S E	See Lamb Bulletin of nput is re	AME routin erg 2006. From g Geological Surv equired in field	ne of the penetic conce ey of Finland s with yellow	HSC Geo epts to practic 402	D
1 2 3 4 5 6 7 8	(E E	See Lamb Bulletin of nput is re n name (AME routin erg 2006. From g Geological Surv equired in fields use following p	ne of the renetic conce ey of Finland s with yellow arts	HSC Geo pts to practic 402	D
1 2 3 4 5 6 7 8 9		Gee Lamb Bulletin of nput is re n name i Cumulus r	AME routin erg 2006. From g Geological Surv equired in fields use following p minerals	ne of the remetic conce ey of Finland s with yellow arts ×	HSC Geo epts to practic 402 v TRUE	D
1 2 3 4 5 6 7 8		Gee Lamb Bulletin of nput is re n name i Cumulus r Drtho/mes	AME routin erg 2006. From g Geological Surv equired in fields use following p minerals	ne of the renetic conce ey of Finland s with yellow arts	HSC Geo pts to practic 402	D

In the Setup worksheet, the ordinal number is given in cell B1. If the number is missing, HSC Geo adds the routine last in the list. The routines which should be run before the routine in question are listed in the D column from D1 downwards.

ക	А	В	С	D	
1	Calculation order	14	Calculations required	VSF	
2				CIPW	
3					
4					
5					
6					

The Input sheet lists the input values required for the calculations. Column A is for the system name. If the input is a chemical analysis, then HSC Geo inputs the assay according to the element's number in the periodic table, i.e. if the input value is for example carbon, then its number is 6 and it will be brought to one row below, i.e. row 7 (the row 1 is for headers; see figure below). The assay will always be transformed to **ELEMENT WEIGHT PERCENTAGES**. For example, if the assay is 1000 ppm CO2, then HSC Geo will change it to 0.0273 % C and send the value 0.0273 to cell C7.

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4	A	B	C	D	E	F	G
1	System	User	Input	Required (1=yes)	Sum	Message	
2					7	7 requred	elment(s) missing
3	He				0		
4	Li 🗘				0		Column C is cleared before each calculations
5	Be				0		Sample data is brought into C-column
6	В				0		
7					0		
8					0		To change the options of required elements
9					0		write 1 for rrequired elements on column D.
0					0		Any other value indicates that element is not required
1					0		Column E calculates the sum in cell E2. If that is 1 or greater
12	Na			1	1		then norm will not be given out and error message is put to Note field
13	Mg			1	1		
14	AI			1	1		
	In II In	fo / Setu	Input	Calc / Output / ?	1/		
Re:	adv		tool have a second	Second and the second			

If the input value is not a chemical assay, then the full name of the value in question has to be written. For example, the CUMNAME routine uses among others the CIPW normative olivine as an input value. Then value "CIPW.Olivine CIPW %" stands for the input value in cell A2 (see below).

C	A	B	C
1	System	User	Input
2	CIPW.Olivine CIPW %		
3	CIPW.Orthopyroxene CIPW %		
4	CIPW.Clinopyroxene CIPW %		
5	CIPW.Plagioclase CIPW %		
6	CIPW.Magnetite CIPW %		
7	CIPW.Apatite CIPW %		
8	CIPW.Chromite CIPW %		
9	CIPW.Ilmenite CIPW %		
10	CIPW.Quartz CIPW %		
11			
12		1	
13			
14			
14 4	▶ ▶ Info / Setup Input	Calc (Dutput 🦯 😏 🖉

The Calc. sheet is an independent calculation sheet not affected by HSC Geo.

The Output sheet has field names in the first column starting from row 2. If the user wishes to change the name, it is better to type the desired name in the column B. If text appears in the column B, that name will be used. Column C is the output value. In most of the built-in routines column C refers to the calculation page. Column D gives the data type for the database.

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- 4	A	В	C	D	E
1	System	User	Output	FIELD	
2	Calculated		False	BOOLEAN	
3	Cumname Full			TEXT(25)	
4	Cumname Simple			TEXT(25)	
5	C1			TEXT(25)	
6	C2			TEXT(25)	
7	C3			TEXT(25)	
8	OMA			TEXT(25)	
9	CRGN			TEXT(25)	
10	IC1			TEXT(25)	
11	IC2			TEXT(25)	
12	IC3			TEXT(25)	
13	Cums %			SINGLE	
14	I-Cums %			SINGLE	
14	🕨 🕅 Info 🤇 Set	up / Inpi	ut Calc	Output 2	/
Rea	ady				

HSC Geo actions in calculation

The calculations in HSC Geo will take place as follows:

- 1. After the input format has been identified and the user presses the Calculate button, HSC Geo will make a list of the calculation routines according to user selections, the ordinal number on the Setup pages and other required calculation routines on the Setup page.
- 2. Before each sample HSC Geo will empty column C on the Input sheet.
- 3. HSC Geo inputs the data in the Input page. For chemical elements the format is ELEMENT WEIGHT PERCENTAGES.
- 4. HSC Geo calls the Recalculate routine.
- 5. HSC Geo reads the calculation results on the Output page and writes the values in the "Calculation Results" window on the page named according to the routine.
- 6. HSC Geo performs steps 2-5 for the next sample.

Routines included

HSC Geo includes the following petrological and mineralogical calculation routines:

- ARRANGE Arrange routine
- ANION Anion proportions
- CATION Cation proportions
- VF Volatile free composition
- SF Composition of the sulfide fraction
- VSF Volatile and sulfide free composition
- CIPW CIPW normative mineral composition
- REE_N Normalization for rare earth elements
- CUMNAME Normative cumulus name for ultramafic-mafic igneous rocks
- TRC Calculate the normative trace element content in igneous minerals of ultramafic-mafic rocks.
- TRACE_N Normalization for trace elements
- ELEMENT Elemental composition
- OXIDE Oxide composition

SF – Sulfide fraction

Normative minerals of the SF, i.e. sulfide fraction, are: pyrrhotite (FeS), pyrite (FeS₂), pentlandite (Ni_{4.76}Fe_{4.24}S₈), chalcopyrite (CuFeS₂), Co-pentlandite (Co₉S₈), arsenopyrite (FeAsS), sphalerite (ZnS), molybdenite (MoS₂) and galena (PbS). In calculation, all of the sulfidic base metals are allotted in a single phase as follows: lead in galena, molybdenum in molybdenite, zinc in sphalerite, arsenic in arsenopyrite, cobalt in Co-pentlandite, copper in chalcopyrite, and nickel in pentlandite. The remaining sulfur and iron are balanced between pyrrhotite and pyrite. The equations and chemical composition of normative sulfide minerals are given in the table below.

When the weight percentages of normative sulfides have been calculated, trace elements bound in sulfides: i.e. Os, Ir, Ru, Rh, Pt, Pd, Au, Re, Ag, Cd, Sn, Sb, Bi, Se, Te and Hg, if analyzed, are added to the sulfides. Recalculation to 100% gives the mineral composition and trace element content of the sulfide fraction. The chemical composition of the sulfide fraction is calculated from mineral abundances as given in the table below (step 8).

If only bulk assays are available, the chemical composition of a sulfide fraction is calculated by setting the pyrite to zero and by following the guidelines given in the table below. Since nickel and cobalt are also bound in non-sulfides, the calculation gives either too high a pentlandite and cobalt pentlandite and consequently Ni and Co content of the sulfide fraction, or residual sulfur ends up negative. In the latter case, all normative sulfides are set to zero and S is allotted to pyrrhotite.

Although the sulfides of a sample may also contain other sulfides than those listed in the table below, such as cubanite, gersdorffite, and various pyrrhotites (troilite, monoclinic and hexagonal), the result of the chemical composition of the sulfide fraction is more accurate and reliable than if a fixed sulfur content were used. If the sulfide fraction is calculated from total analyses, then samples containing less than 2% sulfides must be treated with caution for the above-mentioned reasons.

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Calculation of the sulfide fraction and normative sulfide minerals.

- Weight percentages of chalcopyrite, pentlandite, cobalt pentlandite, sphalerite, galena, molybdenite and arsenopyrite are calculated as given below in the Equation column. Content of elements in equations are weight percentages in the sample.
 Residual sulfur content is calculated. If it is negative, then all sulfides except pyrrhotite are set to zero, and pyrrhotite is calculated according to step 4.
- (3) If Fe analysis is carried out by the bromine-methanol method, then the amounts of pyrite and pyrrhotite are solved as follows: writing in matrix format the mass balance: $\begin{bmatrix} 36.48 & 53.45 \\ 63.52 & 0.07 \times 46.55 \end{bmatrix} \cdot \begin{bmatrix} Po \\ Py \end{bmatrix} = \begin{bmatrix} S \\ Fe \end{bmatrix}$, where S and Fe are residual sulfur and iron contents
- after removing S and Fe bond in previously calculated sulfides. Po and Py are solved by the non-negative least square method.
 (4) If Fe bromine-methanol analysis is not available, or the only Fe sulfide is pyrrhotite, then pyrite is set to zero and the pyrrhotite is calculated according to the equation: Po=100*S/36.48.
- (5) Trace elements in sulfides: Os, Ir, Ru, Rh Pt, Pd, Au, Re, Ag, Cd, Sn, Sb, Bi, Se, Te and Hg are added to the previously calculated sulfides.
- (6) Sum of minerals and trace elements is the normative sulfide content (the word normative may be left out)
- (7) Minerals and trace elements are recalculated to 100%
- (8) Normalization gives the trace element content in the sulfide fraction directly. The Cu, Ni, Co, Zn, Pb, Mo, and As content of the sulfide fraction is back-calculated from the normative minerals. E.g. The Ni tenor: Ni_SF%=Pn_SF%*36.16/100. The iron and sulfur contents are calculated by totaling the sulfur and iron content bound in each normative mineral.

Mineral	Symbol	Formula used	Element	wt.%	Fe wt.%	S wt.%	Equation
Chalcopyrite	Сср	CuFeS ₂	Cu=	34.63	30.43	34.94	Ccp=100*Cu/34.63
Pentlandite	Pn	Ni4.76Fe4.24S8	Ni=	36.16	30.64	33.20	Pn=100*Ni/36.16
Cobalt pentlandite	Cpn	Co_9S_8	Co=	67.40	0.00	52.94	Cpn=100*Co/67.40
Sphalerite	Sp	ZnS	Zn=	67.10	0.00	32.90	Sp=100*Zn/67.10
Galena	Ga	PbS	Pb=	86.60	0.00	13.40	Ga=100*ga/86.60
Molybdenite	Mb	MoS ₂	Mo=	59.94	0.00	40.06	Mb=100*Mo/59.94
Arsenopyrite	Ару	FeAsS	As=	46.01	34.30	19.69	Apy=100*As/46.01
Pyrrhotite	Po	FeS			63.52	36.48	(3) or (4)
Pyrite	Py	FeS ₂			46.55	53.45	(3) or (4)

VF and VSF

The calculation of volatile-free (anhydrous) composition is a common practice in petrological studies of mafic-ultramafic rocks and is a simple recalculation of selected elements to 100%. The main problem is the distribution of total iron between sulfides and the divalent and trivalent states in the rock, forming silicates and oxides. Iron incorporated in sulfides can be solved as described above in the SF routine. The proportion of ferric iron in mafic and ultramafic cumulates is normally low. This only has to be taken into account when chromite, magnetite or ilmenite are present as a cumulus mineral. In this study all non-sulfidic iron was calculated as total FeO in both volatile and volatile- and sulfide-free calculations.

Volatile- and sulfide-free composition (VSF) is the anhydrous chemical composition of the rock where the sulfides have been removed. When the composition of the sulfide fraction has been calculated and the portion of base metals in the sulfides is known, the calculation of volatile- and sulfide-free composition is a simple recalculation of selected elements to 100%. If the composition of the sulfide fraction was determined from the bromine-methanol leach, the recalculation is reliable even for samples rich in sulfides.

The volatile- and sulfide-free composition (VSF) is very useful for Ni-Cu sulfide-bearing samples: it can be applied to compare the host rocks of sulfide-rich samples with ordinary cumulates and country rocks.

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TRC

By mass balance, the concentration of an element E in a multi-phase mineral assemblage can be expressed as the sum of the products of the molar proportions X (as mass fractions of 1) times the concentrations W, of element E, in a mineral phase Ma (Bedard 1994). The weight fraction of element E in a sample is

 $W_{E,T} = \sum_{a=1}^{n} W_{E,Ma} * X_{Ma} \qquad ,$

where $W_{E,Ma}$ is the weight fraction of element E in mineral Ma and X_{Ma} is the weight fraction of mineral Ma in a sample. When the bulk composition ($W_{E,T}$) and weight fractions of minerals (X_{Ma}) are known, one can estimate the weight fraction of the element in mineral $W_{E,Ma}$ by

applying the elemental partition coefficients between the minerals.

CUMNAME

To give the proper cumulus name for an igneous rock is often time-consuming. Thin and polished sections of representative samples have to be studied. However, it has been found that B-normative compositions are in good harmony with the actual primary igneous mineralogy. Consequently, a cumulus naming procedure has been developed on the basis of the CIPW norm.

A comparison of the CIPW norm with the cumulus name defined by microscopy names made it possible to determine the threshold abundances above which minerals belong to a cumulus phase. For normative orthopyroxene, clinopyroxene, and plagioclase it was found to be roughly 25% and for normative olivine 10% (see table below). The sum of the normative cumulus minerals identified in this way is higher than 50% in cumulates, but less than 50% in non-cumulate rocks such as volcanites.

1 Cumulus minerals	2 Cumulus type	3 Cumulus/rock	4 Intercumulus minerals
		index	
Listed in the order of abundance using the following abbreviations. The normative abundance must be above the given boundary. o=olivine (>10%) b=orthopyroxene (>25%) a=clinopyroxene (>25%) p=plagioclase (>25%) m=magnetite (>10%) c=chromite (>0.6%) t=apatite(>1%) \$=sulfides (>0.3%)	If the rock is a cumulate, one of the following symbols is used to describe the amount of cumulus minerals. A=adcumulate (cumulus minerals>93%) M=mesocumulate (cumulus minerals 75-93%) O=orthocumulate (cumulus minerals 50-75%)	To distinguish if a rock is cumulate or non-cumulate: C=cumulate (cumulus minerals >50%) R=non-cumulate rock (cumulus minerals <50%)	Listed in the order of abundance using the following abbreviations The normative abundance must be between the given boundaries. b=orthopyroxene (10-25%) a=clinopyroxene (10-25%) p=plagioclase (10-25%)

Automated cumulus naming procedure

e.g. oMCa=olivine mesocumulate with clinopyroxene as intercumulus mineral; bRpa=non-cumulate rock where the main phase is orthopyroxene and the other significant phases are, in the order of abundance, plagioclase and clinopyroxene

84.7. Modal calculations – mass proportion of minerals in samples

84.7.1. Background and theory

Modal calculation means converting the elemental grades of a sample to mineral grades (Whiten, 2007)⁶. This is also called element to mineral conversion. The method is traditional and provides a simple way to estimate modal mineralogy (i.e. mass proportion of minerals in a sample) by solving simultaneously a set of mass balance equations formulated between chemical elements and minerals. The method is restricted to relatively simple mineralogy where the number of minerals is not larger than the number of analyzed components and the chemical composition of minerals (mineral matrix) is known. Mathematically, this can be written as follows:

$$A \times x = b$$

 $\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \times \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} b_1 \\ \vdots \\ b_n \end{bmatrix}$

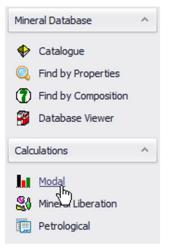
Where A is the matrix on the chemical composition of minerals (Mineral Matrix), x is the vector including the unknown mass proportion of minerals (modal mineralogy) in the sample and b is the vector on the analyzed chemical composition of the sample. The unknown x can be found e.g. using the non-negative least square method (Lawson & Hanson, 1995)².

Element to mineral conversion can be improved by also using, in addition to conventional whole rock analysis, mineral selective methods like bromine-methanol leaching for nickel ores (Penttinen, Palosaari, & Siura, 1977)⁴, copper phase analysis for copper ores (Lamberg, Hautala, Sotka, & Saavalainen, 1997)¹ and Satmagan analysis for iron ores (Stradling, 1991, Lund et al., 2013)^{5,3}.

84.7.2. Simple calculation

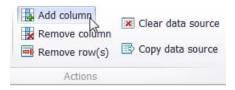
Manual input

To give the chemical assays of samples manually, select Modal calculations.



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In the ribbon, select Add column.



In the Select Elements window, select the elements the assays are for. Additionally, you can also choose other type of analysis such as Satmagan (Sat), Loss of Ignition (LOI), and moisture content (H2O). Alternatively you can also select mineral assays (example: XRD Rietveld results) using the drop down in the bottom left corner. In this example, assays are available for Cu and S. Click on Cu and S and then "Confirm selection."

Select Elements	x
H Method name: He Cu %	
LI BE B C N O F Ne S 76	
Na Mg Al Si P S Cl Ar	
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr	
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe	
Cs Ba Hf Ta W Re Os Ir Pt Au Hg TI Pb Bi Po At Rn	
Fr Ra La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu	
Ac Th Pa U Np Pu Am Cm Bk Cf Es	
▼ ▷ Select LOI Sat H2O ④ Remove	
* dick button to select or type mineral symbol	Cancel

Type in the sample ID and assays in the grid, for example as follows:

	ID	Cu %	S %
	1	1.20	10.30
	2	10.40	22.00
	3	28.00	34.00
۲	4	0.10	8.00
*			



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Calculation Rules

Press "Rules" to define the calculation rules.



In the Calculation window, the periodic table on the top shows the analyzed elements. The next step is to define the minerals. Press Select Minerals on the left side of the window.

Calculation	Error E	stimation	n														
н																He	Element
Li Be											в	С	N	0	F	Ne	
Na Mg											AI	Si	P	S	Cl	Ar	
K Ca	Sc	Ti	v	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb Sr	Y	Zr	Nb	Мо	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Те	I	Xe	
Cs Ba		Hf	Та	W	Re	Os	Ir	Pt	Au	Hg	TI	РЬ	Bi	Po	At	Rn	
Fr Ra		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	ть	Dy	Но	Er	Tm	Yb	Lu	Element Method Accepted
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es					Minerals V LOI Sat H20
Minerals			P	hases ar	nd Eleme	ents per	Rounds										
Select Min	erals			Round 1													🕒 Add Round 😑 Remove Round
				Phases				Elen	nents								
				Method				0.000									
			8	Ueast Weigh Non-n Weigh	ed Leas egative	t Square Least Se	quares (NNLS)	(WNNL	S)							Not Determined 0/0

In Select Minerals, type for instance the mineral name or other search criteria in the first row. Here chalcopyrite is written and Geo shows all the chalcopyrite records

existing in the database. Select the record and press Add or double click the record.

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	1					100	///		Mineral Database	Data
		eader here to grou					/	/	Mineral ID	40
	Mineral ID	Mineral Name 📍	Mineral Symbol	Location	Mineral Key	Statistics	Reference	Sam	Mineral Name	Chalcopyrite
2	=	Blc Chalcop	88 C	8 🖸 C	RBC	8 8 C	8 8 C	1 *	Mineral Symbol	Сср
	25	Chalcopyrite	Сср	Western mines, Vancouver Islan	Anthony et al		251		Location	[stoichiometr.
	40	Chalcopyrite	Сср	[stoichiometric]	CuFeS2				Mineral Key	CuFeS2
T		Chalcopyrite	Сар	Neves Corvo	Graca 1990				Note 3 Database	CuFeS2 HSC
t		Chalcophanite	Cph	[stoichiometric]	ZnMn307*3H			•	SG	4.35
t		Chalcophyllite	Cphy	[stoichiometric]	Cu18Al2(AsO			-	Fe %	30.42976008
ł		Chalcophanite	Cph	[stoichiometric]	FeMn307*3H			- 1	Cu %	34.62601010
			•						S %	34.94422981
ł		Chalcophanite	Cph	[stoichiometric]	Mn2307*3H20			- 1		
4		Chalcopyrite	Сср	Erora, Portugal	DHZ, Vol:5,p		Deer et al.,	-		
(+ + Record	d 2 of 31 → ₩ ₩	• •					<u>۲</u>		
×	Contains	([Mineral Name], 'C	'halcop') 🔻				Edit F	ilter		😵 Graphs
	lected Minera	ls Data								
0		/								
	63									

Continue until all the minerals existing in the samples have been selected. In this example, the minerals are chalcopyrite, pyrite and quartz. Press OK when ready.

	Mineral N	Mineral S	Location	Mineral Key	Si %	Fe %	0 %	Cu %	S %		
	Chalcopyr	Сср	[stoichio	CuFeS2		30.42942		34.62563	34.94493		
1	Pyste	Py	[stoichio	FeS2		46.54642			53.45357		
	Quartz	Qtz	[stoichio	SiO2	46.74349		53.25650				

The next step is to define the rules for calculations. In this case, the rules are as follows:

- Chalcopyrite and pyrite are calculated from the Cu and S assays
- Quartz is the remaining, i.e. 100-others

Select the minerals (chalcopyrite and pyrite) and press to move them to the list of phases (in Round 1).

Minerals	Phases and Elements per Rounds
Select Minerals	Round 1
	Phases
Chalcopyrite ([stoichiome	Chalcopyrite ([stoichiometric])
Pyrite ([stoichiometric]) Quartz ([stoichiometric])	Pyrite ([stoichiometric])

Now select the elements, i.e. click on Cu and S to move them to the list of elements. The color of Cu and S changes to red indicating that they have been used in the calculations.

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Calculation Error Estimation				
н			He	Element
Li Be		ВС	N O F Ne	S %
Na Mg		Al Si	P S Cl Ar	
K Ca Sc Ti V	/ Cr Mn Fe Co	Ni Con Zn Ga Ge	As Se Br Kr	
Rb Sr Y Zr I	lb Mo Tc Ru Rh	Pd Ag Cd In Sn	Sb Te I Xe	
Cs Ba Hf 1	a W Re Os Ir	Pt Au Hg TI Pb	Bi Po At Rn	
Fr Ra	Ce Pr Nd Pm Sm	Eu Gd Tb Dy Ho	Er Tm Yb Lu	Element Method Accepted
Ac 1	'h Pa U Np Pu	Am Cm Bk Cf Es		Minerals V LOI Sat H20
Minerals	Phases and Elements per Rounds		-	
Select Minerals	Round 1			🕒 Add Round 😑 Remove Round
	Phases	Elements		
Chalcopyrite ([stoichiome Pyrite ([stoichiometric])	Chalcopyrite ([stoichiometric])	Cu %		•
Quartz ([stoichiometric])	Pyrite ([stoichiometric])	S %		4
4				<u> </u>
14				
•				
<i>Q</i>	-			
		1		
Press "Add Rou	und" 🔁 Add Round	to add another	round for quart	Ζ.
			2	

Select and move quartz to the list of phases and press \sum to set quartz as the remaining, i.e., 100 – (Chalcopyrite + Pyrite). The calculation rules are now defined. In Reset

case you want to reset these rules, you can press Reset

Phases and Elements per Rounds		
Round 1 Round 2	🕒 Add Round 🖨 Remove Ro	ound
Phases	Elements	
Quartz ([stoichiometric])	Sum = 100%	
		1
		-
Method		
Q Least Squares (LS)	Exactly Determined 1/1	
 Weighed Least Squares (WLS) Non-negative Least Squares (N 		
Weighed non-negative Least Squares (N		

Press Calculate

Metso

Modal	Calculations
	Calculate
Ex	amples 👻
٩	Export
4	Import

Studying the calculation result

The result is shown in seven tabs:

- Modal gives the mineral mass proportions (wt%)
- Distribution is for calculating the distribution of elements between the minerals
- Fraction is for calculating the composition of a given mineral fraction
- Residual gives the residue of the calculation
- Bulk Ch. gives the back-calculated chemical composition of the samples
- Notes/Statistics is for error estimation
- "Initial values" shows the sample analyses and mineral matrix

In the Modal sheet, each sample is listed horizontally, mineral grades are given as wt%, the total is displayed, and SG is the calculated specific gravity (density) of the sample. Please note that when calculating density, the missing part (i.e. if the sum is below 100) is not taken into account. The calculation is made as if the modal mineralogy were normalized to 100%.

Data	Source 🔻	Mo	dal Dis	tribution	Fraction	Residua	al Bulk Ch	. Note	s/Statistics	Initial values
			Α	В	С	D	E	F	G	н
	Data	1	ID	Ccp %	Ру %	Qtz %	Total	SG		
0		2	1	3.466	17.004	79.531	100.000	2.924		
	Rules	3	2	30.035	21.523	48.442	100.000	3.392		
	. tones	4	3	80.864	10.743	8.392	100.000	4.184		
9===		5	4	0.289	14.778	84.934	100.000	2.852		
	Result	6								
		7								

Instead of selecting one mineral to be the remaining (as quartz in this example), the modal result can also be normalized proportionally so that the sum of all minerals become 100%. This is done by selecting normalize in the top ribbon.

	🔀 Graph	Select minerals to normalize	x
		Minerals / Phases	Normalize to
Copy sheet	Normalize	Chalcopyrite ([stoichiometric])	 Total sum is: Sum of selected phases is:
Geo Tools			100
Mineral Data	abase ^		
😔 Catalo	gue		Cancel Calculate

In the pop up window, you can select on how the result should be normalized. You can either select the total sum of the minerals to be 100 (adjustable) or select phases to sum up to a certain amount.

To calculate the distribution of any element between minerals, select the Distribution tab and select the element from the periodic table.

Mor	gl Distributio	n Fraction	Residual	Bulk Ch.	Notes/	Statistics	Initia	al values						
н	0		Distrib	ution of F	e								He	
Li	Be							в	С	N	0	F	Ne	
Na	Mg							AI	Si	P	s	d	Ar	
ĸ	Ca Sc	Ti V	Cr Mn	Fe	Co Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr Y	Zr Nb	Mo	Ru	Rh Pd	i Ag	Cd	In	Sn	Sb	Te	1	Xe	
Cs	Ba	Hf Ta	WRe	Os	Ir Ir	Au	Hg	TI	Pb	Bi	Po	At	Rn	
Fr	Ra		De Nid			64	1		11-	5	Ter	1		
		La Ce	Pr Nd	Pm	Sm Eu	Gđ	ть	Dy	Но	Er	Tm	Yb	Lu	
		Ac Th	Pa	Np	Pu Ar	m Cm	Bk	ď	Es	Fm	Md			
	А	В	С		D	E		F		G		H	4	1
1	ID	Ccp %	Py %	Qtz	%	Total								
2	1	11.75792	88.242	08	0	- 1	.00							
3	2	47.70866	52.291	34	0	1	.00							
4	3	83.11237	16.887	63	0	1	.00							
5	4	1.261527	98.738	47	0	1	.00							
6														
7														

To calculate the composition of a mineral fraction, select the Fraction tab, select and move the minerals to the list of minerals in the fraction and press "Calculate Fraction." Minerals in the fraction are normalized to 100% and the chemical composition of the mineral fraction is displayed. The fraction is used for estimating the composition of bulk sulfide concentrate, for example.

Copy sheet	Save A	Stream S												
Geo Tools		Modal Calcul	ations 🛪	۲										
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 Catalogue Find by Properties 			Data			ichiometric])				Þ	Chal	copyrite ([stoichiometric])
 Find by Composition Database Viewer 		() () () () () () () () () () () () () (Rules								DI D	****		
Calculations	^	R	lesult								И		Fraction	Ccp+Py
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Mineral Liberation				2	1	16.931								
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Petrological		Example		4	3	88.272	41.745 11.728	100.000 100.000	37.158 32.320	20.172 30.565	42.671 37.115	4.604 4.419		
(Petrological		Example Example	es 🔻	4 5 6 7 8	3	88.272	41.745 11.728	100.000 100.000	37.158 32.320	20.172 30.565	42.671 37.115	4.604 4.419		
(Petrological		Example Example Exp	es 🔻	4 5 6 7	3	88.272	41.745 11.728	100.000 100.000	37.158 32.320	20.172 30.565	42.671 37.115	4.604 4.419		

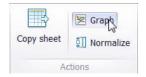
Residual (in the Residual tab) shows the residue of the calculation. You can display the result either on an Absolute or Relative basis.

Copy sheet Calculation type: Absolute Relative Actions	Save Stream As HSC Stream							
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Mineral Database	Data S	Data Source 🔻		dal D	istribution	Fraction	Residu	al Bu
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2 Database Viewer		Kules	4		3 1.13E-	11 2.888	-11	
			5		4 4.12E-	14 -3.188	-12	
Calculations		Result	6					

Bulk Chemistry (in the Bulk Ch. Tab) shows the chemical composition of the sample when back-calculated from the modal composition (x) and chemical composition of minerals (A matrix).

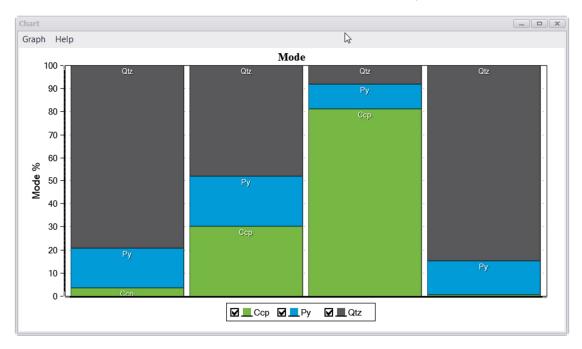
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Α	В	С	D	E	F	G	н	1
ID	Si %	Fe %	0%	Cu %	s %	SG		
1	37.175	8.969	42.355	1.200	10.300	2.924		
2	22.644	19.158	25.799	10.400	22.000	3.392		
3	3.923	29.608	4.470	28.000	34.000	4.184		
4	39.701	6.966	45.233	0.100	8.000	2.852		
	A ID 1 2 3	A B ID Si % 1 37.175 2 22.644 3 3.923	A B C ID Si % Fe % 1 37.175 8.969 2 22.644 19.158 3 3.923 29.608	A B C D ID Si % Fe % O % 1 37.175 8.969 42.355 2 22.644 19.158 25.799 3 3.923 29.608 4.470	A B C D E ID Si % Fe % O % Cu % 1 37.175 8.969 42.355 1.200 2 22.644 19.158 25.799 10.400 3 3.923 29.608 4.470 28.000	A B C D E F ID Si % Fe % O % Cu % S % 1 37.175 8.969 42.355 1.200 10.300 2 22.644 19.158 25.799 10.400 22.000 3 3.923 29.608 4.470 28.000 34.000	A B C D E F G	A B C D E F G H ID Si % Fe % O % Cu % S % SG 1 37.175 8.969 42.355 1.200 10.300 2.924 2 22.644 19.158 25.799 10.400 22.000 3.392 3 3.923 29.608 4.470 28.000 34.000 4.184

Pressing "Graph" on different sheets (Modal and Distribution sheets) will show the result in a graphical format.



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Error Estimation

In the modal calculation, you can also take into account the analytical and sampling errors involved in obtaining the chemical assay. This is done in Error Estimation window under "Rules". The calculation rules must already be defined before doing error estimation.

UBB 300000 IN]	Calculation E	Error Estimation								
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No. 000		Na Mg					Al Si	PS	Cl	Ar	
Result March March March March March March March March March March March March March March March March March March March March	Rules	K Ca S	Sc Ti V Cr	Mn Fe	Co Ni	📃 💽 Zn	Ga Ge	As S	e Br	Kr	
A B C D E F G H I		Rb Sr 1	Y Zr Nb Me	Tc Ru	Rh Po	Ag Cd	In Sn	Sb T	e I	Xe	
Bai Bai <td>Result</td> <td>Cs Ba</td> <td>Hf Ta W</td> <td>Re Os</td> <td>Ir Pt</td> <td>Au Hg</td> <td>TI Pb</td> <td>Bi P</td> <td>o At</td> <td>Rn</td> <td></td>	Result	Cs Ba	Hf Ta W	Re Os	Ir Pt	Au Hg	TI Pb	Bi P	o At	Rn	
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Press "Regenerate CV-tables" to generate the coefficient of variations (CV) for the analyses. CV is also known as relative standard deviation (RSD).

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Calc	ulation	n Round	ds	50 🗘										
	A	В	С	D	E		F	G		н	1	J	К	1
1	Id	Cu %	S %											
2	1	4	4											
3	2	4	4											_
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5	Cu		_	1									_	
6	S		_	1	1								_	
7	-		_										_	
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9			_								_		_	
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The top sheet refers to the relative standard deviation (RSD) of the chemical analysis of each sample (example: XRF analysis). In this case, we have the chemical analysis of Cu and S respectively for all four samples.

The bottom sheet refers to the relative standard deviation (RSD) of the elemental analysis of each mineral (example: electron microprobe analysis). In this case, we have defined the minerals to be Chalcopyrite, Pyrite, and Quartz. Each elemental analysis for each mineral has its own RSD.

After entering all the RSD values accordingly, you can adjust how many calculation rounds that you want. Then press "Run Monte Carlo Simulation". The result is available in "Notes/Statistics" tab under "Result".

Data Source 🔻	Moda	al Dist	ribution	Fraction	Residual	Bulk Ch	. Notes/Sta	atistics	Initial values				
	Note	es Sta	tistics										
Data		А	E	3	С		D		E	F	G	н	^
	1	ID	Ccp %		Py %	Qt	2 %	Total					
Rules	2	1.000	3.717±0	0.480	17.248±0.4	463 79.	036±0.943	100.0	000±0.000				
	3	2.000	30.230:	±1.057	21.578±0.	209 48	191±1.244	100.0	000±0.000				
Result	4	3.000	81.482:	±1.299	10.787±0.	297 7.7	31±1.343	100.0	000±0.000				
	5	4.000	0.281±	0.133	14.750±0.	555 84	970±0.688	100.0	000±0.000				
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The result of the error estimation is given in five tabs:

- Average ± 1 Sigma gives the modal calculation results in the form of average modal mineralogy plus minus the standard deviation.
- Average gives the average modal mineralogy
- StdDev gives the standard deviation of the modal mineralogy

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- Min-Max gives the minimum and maximum range of the modal mineralogy.
- CV gives the CV / RSD of the modal mineralogy.

Monte Carlo Simulation for Error Estimation

In principal, the Monte Carlo method simulates a distribution of input data to a model, so that the output of the model can be given as a probability distribution of possible outcomes. The model here is the element to mineral conversion routine; we want to see the modal mineralogy if the chemical assays and elemental analysis of the minerals is not a single value, but rather a distribution of multiple values with a certain variability.

This is very useful since in real life, we would not have just one chemical assay; we usually repeatedly perform chemical assays and in some cases with multiple samples. Since assays costs money, it would be unfeasible to perform a large amount of assaying just to evaluate the variability and its effect to the modal mineralogy calculation. However, if we understand the typical variability of the assays, we can use this knowledge to simulate a large amount of assay to be used for modal mineralogy calculation.

84.8. References

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