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Brochure on Mineral Liberation Analysis (MLA) Geometallurgy Laboratory Freiberg

Laboratory equipment: The Freiberg Geometallurgy Laboratory operates a Scanning Electron Microscope (SEM) FEI Quanta 600 MLA-FEG equipped with two parallel Bruker X-Flash EDS detectors and software versions of the MLA 2.9 and MLA 3.1 program by FEI. The laboratory has a high vacuum carbon coating system. A fully equipped Preparation Laboratory for all sample preparation and polishing is available at the Helmholtz Institute Freiberg.

Requested sample sizes: For preparation of grain mounts in epoxy blocks we request a minimum of 10 g of dried mineral sands, mineral processing products or other samples composed of mineral grains. As the maximum sample size we recommend 100 g. At larger sample sizes we split the samples by simple and time-saving methods.

Sample preparation: Aliquots of 10 - 20 g of a sample will be mixed with pure graphite powder to prevent particle cohesion and embedded in epoxy blocks. The preferred diameter of the round blocks is 30 mm; diameters of 25 and 40 mm are optional. Dependent on the analytical task, multiple epoxy blocks are fabricated. Samples with marked effects of mineral segregation by gravity are mounted twice, generating an analytical surface without artifacts of gravity separation.

The analytical surface of the epoxy blocks is grinded and polished in several steps until the demands of electron-beam imaging and analysis are matched. The polished samples are cleaned and coated with carbon.

Analytical alternatives and special features: The Mineral Liberation Analysis (MLA) by SEM analysis of the samples allows several automated procedures based on Backscattered Electron Image (BSE) inspection and collection of Energy Dispersive X-ray-Spectra (EDS) of the particles visible in BSE-imaging mode. The recommended minimum particle size is 5 µm for a routine automated inspection. Special arrangements allow smaller particle sizes of 1 µm to be investigated.

The automated routine analytical protocol gains ED spectra from 200 000 particles with average P50 particle size of 30 µm within 6 hours of measurement. Other analytical routines allow to search for PGE ore, gold or other defined mineral grains (e.g. monazite, apatite, garnet) in grain mounts and thin sections. For the mineral list the collected ED spectra are classified with a standard spectra list which has been collected and specified from the samples. The generation of the standard spectra list for the mineral classification is charged extra for each ore type or analytical task. When customers send in further samples of the same ore type or type of study, the Standard Database can be used without extra cost.

Limits of analytical method: The Mineral Liberation Analysis on epoxy grain mounts by SEM-FEG has several limits which arise from mineralogical, elemental and preparation issues: Several light elements as Li can not be analysed. Graphite and coals are very problematic to analyse due to graphite and C in the epoxy resin. Also it is hard to distinguish magnetite, hematite and Fe-hydroxides due to their similar EDX spectra. Special methods to overcome the C and Fe-oxide problem exist, but require special and expensive treatment and may fail in some cases.

Presentation of analytical results: The analytical results are presented in numerous XLS spreadsheets and JPG graphs. See appended assignments. This encloses the mineral list and the **modal mineralogy**. For the mineral list, the minerals of minor importance or interest can be grouped. Mineral species of interest (e. g. Cu sulphide ores) can be listed in detail. The **grain sizes** of each specified mineral phase can be shown and distinguished, even when the phase is blinded or intergrown with other phases. Customers can define the minerals of their special interest to be treated.

The **mineral liberation** characteristics are given in several displays:

(1) The **mineral locking** XLS-list and graphs note how many wt% of a given phase (e. g. chalcocite) occur with which other phase in binary and tertiary composed particles.

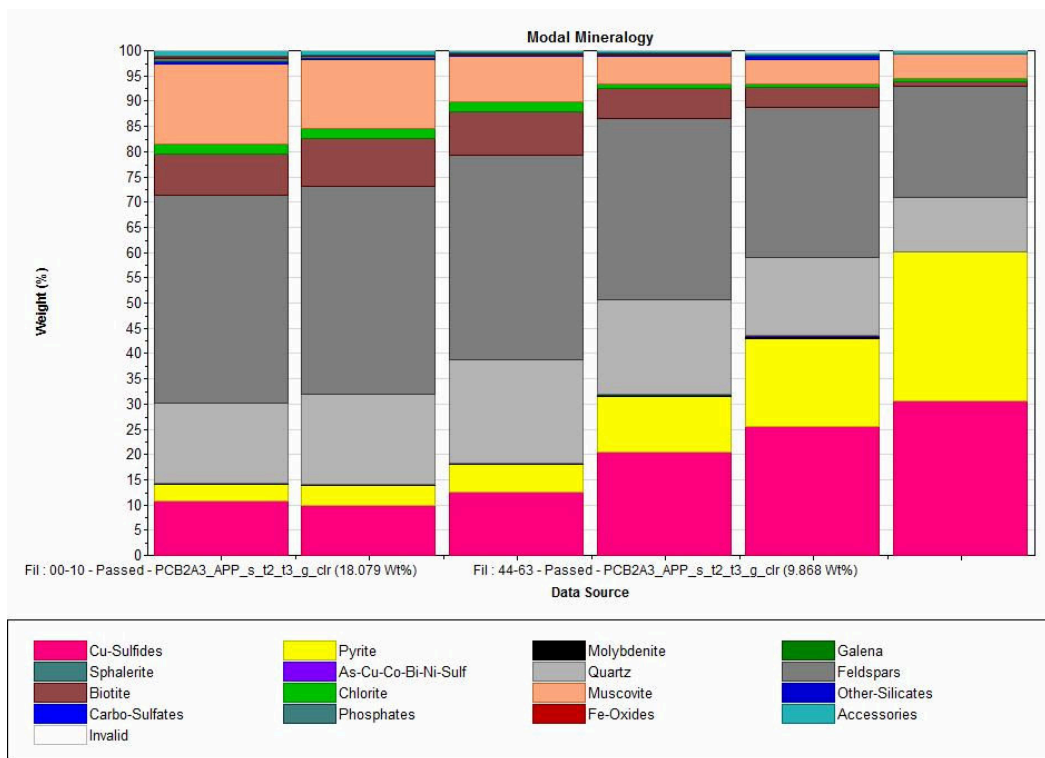
(2) The **mineral liberation by particle composition** indicate how many weight % of a given phase occurs in a given liberation class. E.g. there are particles of liberation class 95-100 % which are composed by 95 wt% of Cu-sulfide ore and 5 wt% of gangue minerals. The share of the particles belonging to this liberation class is plotted in cumulative way.

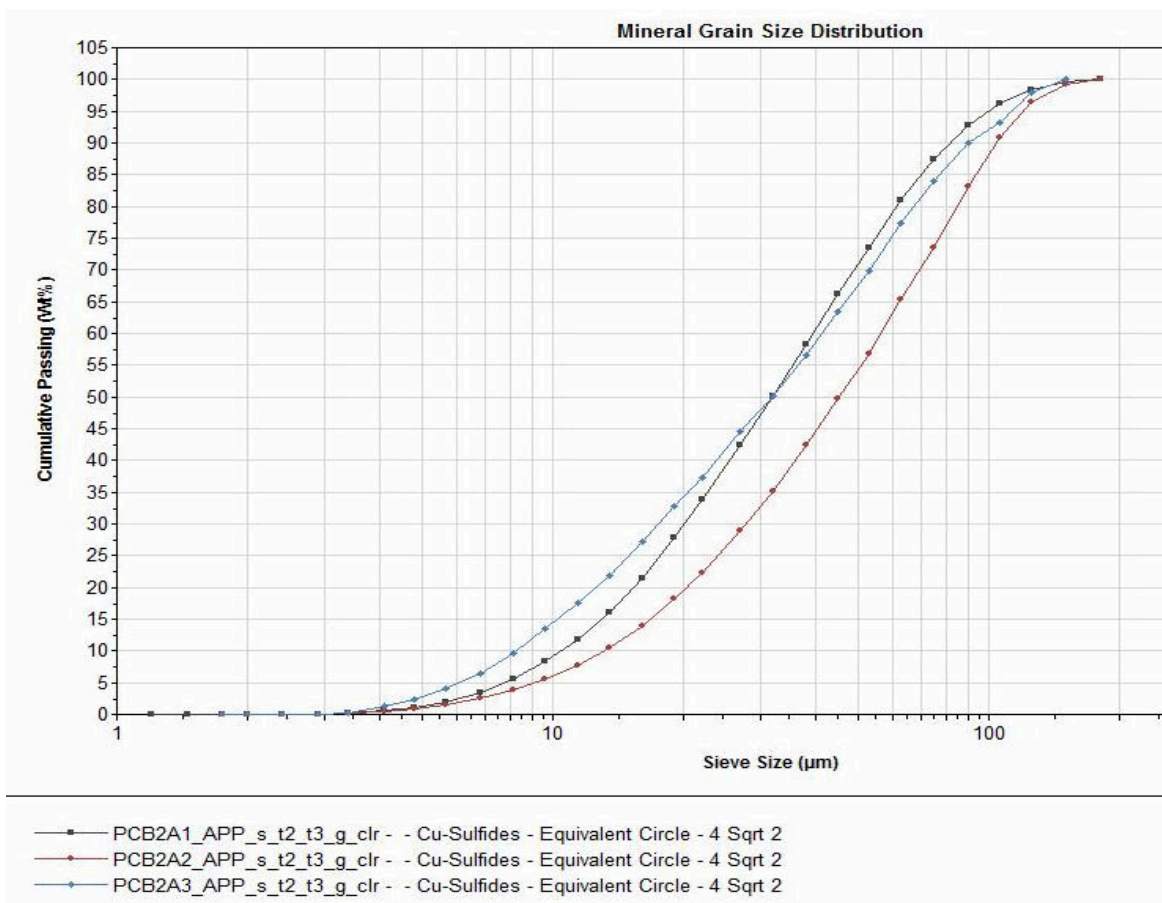
(3) The **mineral liberation by free surface** list and graph indicate how many particles with free surface of a given phase occur in a given liberation class. E.g. Cu-sulfide ore occurs in particles with a completely free surface (liberation class 100), a surface locked by 5 % by a gangue phase (liberation class 95-100) or a completely locked surface (liberation class 0). The share in wt% of the particles belonging to this liberation class is plotted in cumulative way.

Other parameters which can be extracted from the data are the **mineral density distribution** curve or the **mineral phase and elementary grade vs. recovery** curves. These parameters are recalculated according to the mineral phase characteristics (density and elemental composition) which are entered into the standard database. From smaller datasets all the geometrical grain size parameters in 2D can be extracted. The data also allows it to inspect selected single grains in **frame view** and **grain and particle line-ups**.

Electronic (virtual) sieving: It is routine to examine the mineral liberation data set gained from a bulk sample in any grain size classes. This is performed by an "electronic sieving" procedure. The parameters of this virtual sieving can be chosen, for instance as particle long diameter (which is similar to natural sieving) or a defined square. Also the step sizes of the sieve can be chosen. All the parameters mentioned above can be extracted and presented for each electronic sieve class.

	A	B	C	D	
1	Data Source: PCB2-A1-A2-A3				
2	Mineral Groupings: Ungrouped				
3	Mineral	PCB2A1_APP_s_t2_t3_g	PCB2A2_APP_s_t2_t3_g_clr - Wt%	PCB2A3_APP_s_t2_t3_g_clr - Wt%	PCB2A1
4	Bornite	9,12	5,33	2,35	
5	Chalcocite	22,43	15,30	4,80	
6	Chalcopyrite	25,44	18,57	6,42	
7	Covellite	1,39	1,44	0,61	
8	Pyrite	20,91	15,25	7,26	
9	Molybdenite	0,51	0,33	0,32	
10	Galena	0,01	0,01	0,00	
11	Sphalerite	0,01	0,01	0,00	
12	As-Cu-Co-Bi-Ni-Sulf	0,05	0,03	0,01	
13	Quartz	4,36	10,03	17,88	
14	Feldspars	9,65	21,62	38,57	
15	Biotite	1,58	3,75	7,77	
16	Chlorite	0,39	0,92	1,68	
17	Muscovite	2,98	6,09	10,67	
18	Other-Silicates	0,01	0,02	0,02	
19	Carbo-Sulfates	0,54	0,46	0,40	
20	Phosphates	0,10	0,18	0,30	
21	Fe-Oxides	0,13	0,16	0,27	
22	Accessories	0,37	0,45	0,63	
23	Invalid	0,03	0,05	0,04	
24	Total	100,00	100,00	100,00	
25					





	A	B	C	D	E	
1	Data Source: B4F-B5F					
2	Mineral Groupings: Ungrouped					
3	Mineral: Chalcocite					
4	Data Type: Weight%					
5	Tolerance %: 5					
6	Table Type: Mineral Locking					
7	Chalcocite Weight % locked in...	F1B4-F - Binary Particle (%)	F1B5-F - Binary Particle (%)	T1B4-F - Binary Particle (%)	T1B5-F - Binary Particle (%)	CCB4-F -
8	Bornite	2,52	2,36	2,55	2,33	
9	Chalcopyrite	1,51	1,43	1,62	1,39	
10	Covellite	0,48	0,77	0,66	0,61	
11	Pyrite	0,23	0,32	0,43	0,20	
12	Galena	0,27	0,38	0,26	0,36	
13	Sphalerite	0,08	0,06	0,04	0,02	
14	As-Cu-Co-Ni-Sulfide	0,03	0,03	0,02	0,04	
15	Quartz	3,93	2,66	4,67	4,93	
16	Feldspars	1,84	1,21	2,21	2,71	
17	Phyllosilicates	3,16	2,62	4,34	3,98	
18	Other-Silicates	0,00	0,00	0,00	0,01	
19	Calcite	0,83	0,46	0,78	0,69	
20	Dolomite	4,66	3,14	5,56	5,92	
21	Anhydrite	0,10	0,03	0,07	0,09	
22	Baryte	0,04	0,08	0,07	0,02	
23	Phosphates	0,05	0,03	0,01	0,01	
24	Fe-Oxides	0,00	0,00	0,00	0,00	
25	Accessories	0,03	0,03	0,08	0,05	
26	Invalid	0,00	0,00	0,01	0,01	
27						

