

BGRIMM Process Mineralogy Analyzer

Introduction

The BPMA (BGRIMM Process Mineralogy Analyzer) is the latest software platform for automated identification and quantification of minerals, which is developed independently by the State Key Laboratory of Process Automation in Mining & Metallurgy, BGRIMM Technology Group (China). The BPMA software enables selected scanning electron microscopy (SEM) equipped with energy dispersive X-ray spectrometry (EDS) to become a fully automated process mineralogy analyzing system. The BPMA software controls SEM & EDS through the application programming interfaces (API) to form an auto-SEM & EDS system and combines back-scattered electron (BSE) image and X-ray spectrum analysis to classify minerals, and investigate process mineralogical data (e.g., mineral composition, mineral abundance, mineral liberation and intergrowth relationships, mineral associations, particle sizes and grain sizes, particle density distributions, calculated assay, elemental deportments, mineral grade recovery and elemental grade recovery, etc.) automatically; It can be used for automated quantitative mineralogical investigation of samples such as rocks, coals, ores, concentrates, tailings, smelter products, fly ash and red mud.



Fig.1 BPMA system based on ZEISS EVO18 SEM and Bruker QUANTAX 200 EDS at the BGRIMM Technology Group (Figure provided by Prof. M.X. Jia)

BPMA is mainly used to investigate the quantitative mineralogical data and mineral processing-relevant parameters in granular ore samples (e.g., Cu, Pb, Zn, W, Sn, Mo, Bi, Ni, Fe, V, Ti, P, etc.) to aid mineral processing plant surveys, plant monitoring, process design, and process optimization. With advanced function of target particle positioning and returning, BPMA is especially suitable to search for low-grade and micro fine-grained rare and precious minerals such as Au, Ag, REEs, PGEs, Nb, Co, etc., via the specific particle analysis (SPLA) mode. Besides, it can also be used for ore characterization in coal, fly ash, red mud, smelting slags, seabed manganese nodules, rocks and other solid materials. In addition, we can identify minerals that are rather exotic, with complex optical properties, low abundance or small grain size quickly using BPMA system.

Hardware & Software

SEM	EDS	BPMA software
Optional • Tungsten Filament • Field Emission Gun	Optional • Single Detector • Dual Detector • Four Detector	Optional • Online version – Acquisition software • Offline version – Processing software
Recommended • TESCAN VGA GMS (Tungsten) • TESCAN MIRA GMS (FEG) • ZEISS EVO18 / EVO15 (Tungsten) • ZEISS Sigma300 / Sigma500 (FEG) • Thermo Scientific Apreo 2C / Apreo 2S (FEG) •	Recommended • Bruker QUANTAX 200 (dual XFlash®7 30 detector) • Bruker QUANTAX 200 (XFlash®7 60 detector) • Thermo Scientific NORAN System 7 – UD60 •	

Mineralogical Data Presentation

The various quantitative process mineralogical data includes but is not limited to the following would be generated:

- (1) Mineral composition;
- (2) Mineral abundance;
- (3) Particle size distributions;
- (4) Grain size distributions;
- (5) Mineral liberation (by particle composition and/or free surface);
- (6) Mineral locking (locking particle and interlocking relationships);
- (7) Mineral associations;
- (8) Particle density distributions;
- (9) Element concentrations;
- (10) Element distributions;
- (11) Grade and recovery curves calculated for target minerals;
- (12) Grade and recovery curves calculated for target elements.
- (13) Automatic rocks classification and nomenclature according to acquired mineral abundance and / or element concentrations.

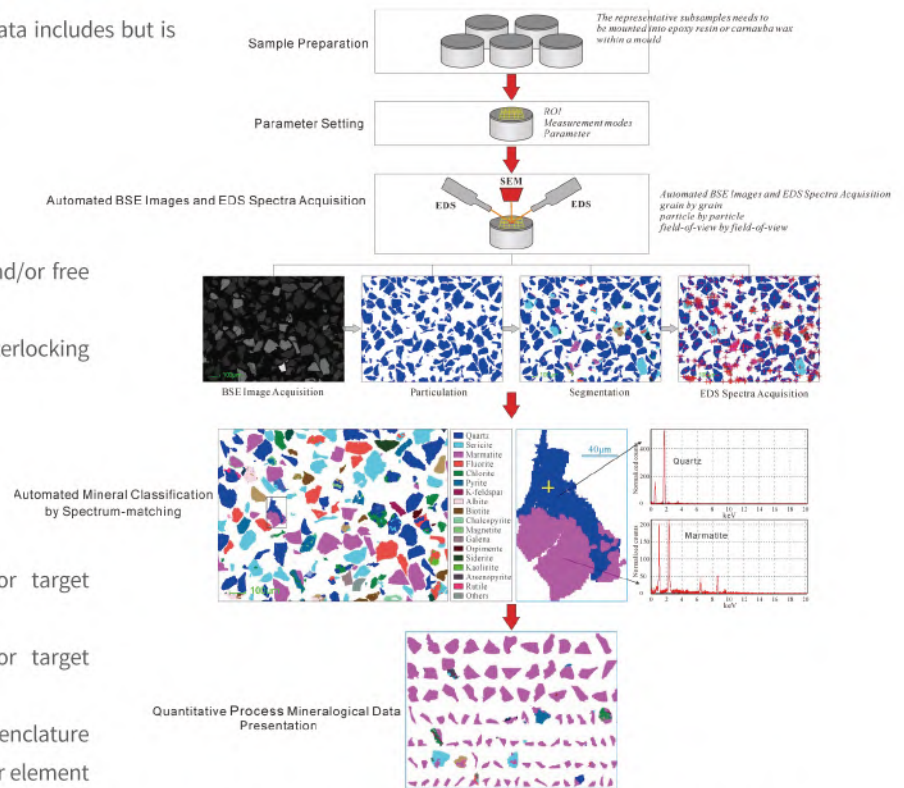
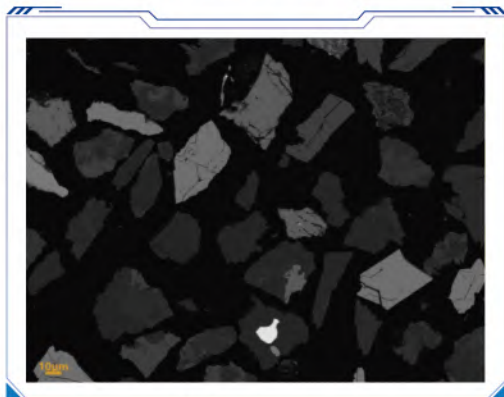
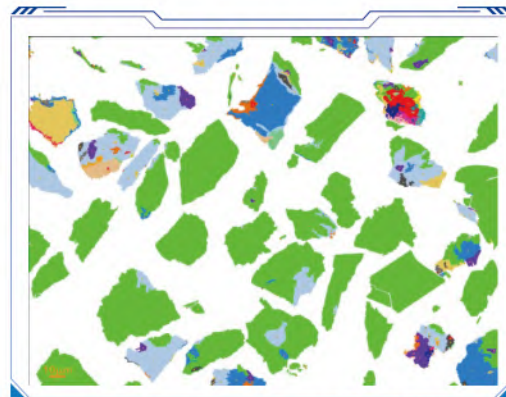


Fig.2 Flowchart of a BPMA measurement in the case of particulate materials (grain mounts).

Measurement Mode



(a) BSE Image

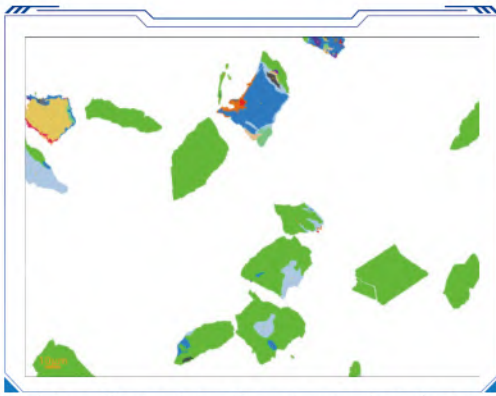


(b) Particle Liberation Analysis (PLA)

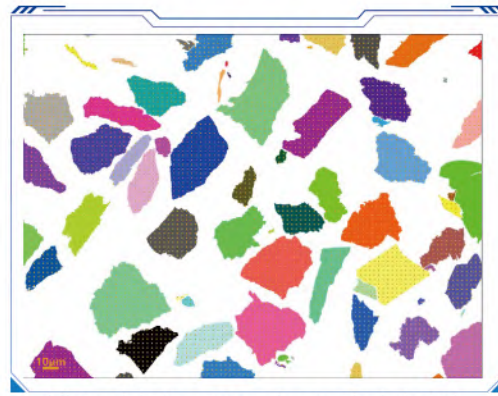
There are several predefined measurement modes that are available in the BPMA software platform, each designed for specific applications.

● Particle Liberation Analysis (PLA)

The PLA mode is the most commonly used liberation analysis method. This mode is used for detailed mineralogical investigation of all particles in the sample. In this mode, a BSE image is obtained for each field-of-view and analyzed to determine each particle-section perimeter, area, and location within a field-of-view. The PLA mode undergoes the BSE image analysis and collects EDS spectra from all collecting points or segments. The high resolution of BSE image for grain boundary definition make PLA method applicable to a great majority of ore samples, especially those containing sulfide, silicate or natural elements. For the samples with extremely low target mineral content, a large number of tests or supplements with Specific Particle Liberation Analysis (SPLA) mode are needed.



(c) Specific Particle Liberation Analysis (SPLA)



(d) Particle X-ray Mapping Analysis (PMA)

● Specific Particle Liberation Analysis (SPLA)

The SPLA mode, is identical to the PLA mode, except images are created only for specific particles that contain target minerals (or target elements) by the specified BSE gray levels and/or specified elements, and thus no interested particles would be removed.

- ▶ Specified BSE gray levels
- ▶ Specified elements
- ▶ Specified BSE gray levels + Specified elements

● Particle X-ray Mapping Analysis (PMA)

● Coal Sample Analysis (CSA)

● Bulk Sample Analysis (BSA)

Application Field

Process Mineralogy

(Mineral processing plant surveys, plant monitoring, process design, and process optimization.)

Ore Beneficiability Evaluation

(Research on ore properties, ore mineral composition and evaluation of ore beneficiability in geological exploration and mine geological work)

Mineral Processing Experiments

(Analyzing the liberation degree of grinding products under different grinding conditions; inspecting the state of impurity minerals entering the concentrate; analyzing the reasons for the loss of the target minerals)

Tracking and positioning for low-grade and micro fine-grained rare and precious metal minerals such as Au, Ag, REEs, PGEs, etc.



Metallurgical Modeling & Geological Metallurgy

Smelting slag, Fly ash, Red mud

(Import and export inspection of mineral solid wastes; Comprehensive utilization)

Automated Mineralogy in Petrology (Geology)

(high-resolution quantitative mineral characterization of thin section or polished rock surface)

Identification of exotic / undetermined minerals

Comprehensive utilization of mine resources

Quantitative Mineral Characterization in Coal

(coal, coal gangue, crystalline graphite)

Applications in oil and gas, environmental protection, forensic geology, soil, archaeology and other fields

Key Features

- Automatic, Efficient, Quantitative, & High-resolution.

The BPMA system, measurements based on BSE image and X-ray spectrum analysis, could be used to investigate the quantitative process mineralogical data quickly, accurately and automatically. The measurement process is highly automated, fast, with large number of statistical sample and few human influence factors; The result is informative, accurate and repeatable. Generally, more than 10,000 mineral particles can be scanned automatically in less than an hour for a routine ore sample, and its resolution can reach micron-submicron. Meanwhile, any particles of interest can be relocated for high-resolution microscopic morphology observation and in situ chemical composition analysis using the high-resolution scanning electron microscopy (SEM) and energy dispersive X-ray spectrometry (EDS).

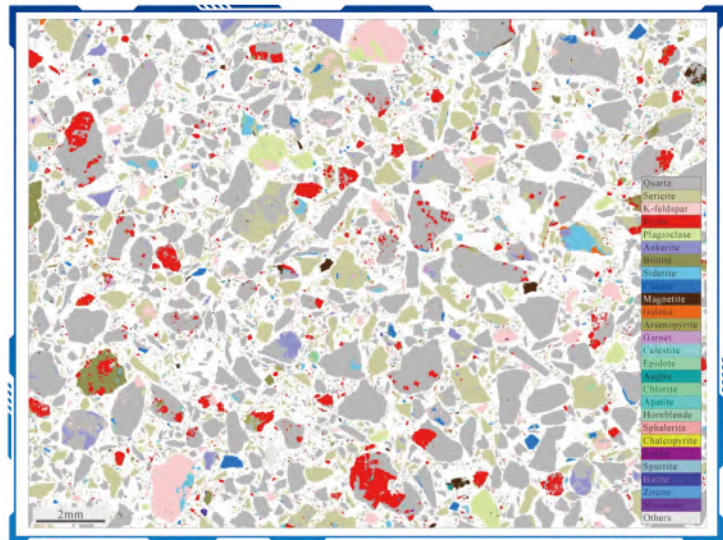


Fig.4 False-coloured mineral map of an altered rock-type gold ore sample by BPMA analysis.

- Forward-thinking Mineral Identification. The innovative mineral identification method by spectrum-shape-matching, spectrum-position-matching and spectral fingerprint-peak matching are employed in the BPMA system to identify minerals automatically and accurately.

- Innovative mineral classification method for “mixed spectrum” . The BPMA employs unique matching method based on the specified X-ray line position of the specified element, and has strong mineral “mixed spectrum” classification ability.

- Advanced and unique BSE image analysis allow accurate Particulation and Segmentation.

- Comprehensive mineral library (> 3000 minerals) for mineral identification.

- Advanced tracking and positioning can be successfully applied to search for low-grade and micro fine-grained rare and precious metal minerals (e.g. Au, Ag, REEs, PGEs, etc.).

- Special analysis mode for coal sample. It is suitable for automated identification and quantitative characterization of ash types in coal raw materials, crystalline graphite and other carbonaceous ore samples.

- Allow unattended 24-hour continuous work. Multiple samples can be loaded and measured only one time. After the previous sample is measured, the next sample will be measured automatically.

- Available different SEM & EDS hardware. The BPMA software platform was originally developed based on ZEISS EVO18 SEM and Bruker QUANTAX 200 EDS. The software can be used both online and offline. It is available multiple-choice SEM & EDS combinations that open API interface to users. To date, the BPMA software enables the following SEM & EDS: 1) SEM: TESCAN VGA3 XMU (Tungsten), TESCAN MIRA3 XMH (FEG), TESCAN VGA GMS (Tungsten), TESCAN MIRA GMS (FEG); ZEISS EVO18 / EVO15 (Tungsten), ZEISS Sigma300 (FEG), Thermo Scientific (FEI) Apreo 2 S HiVac (FEG), etc.; 2) EDS: Bruker QUANTAX 200, Thermo Scientific NORAN System 7 – UD60, etc.

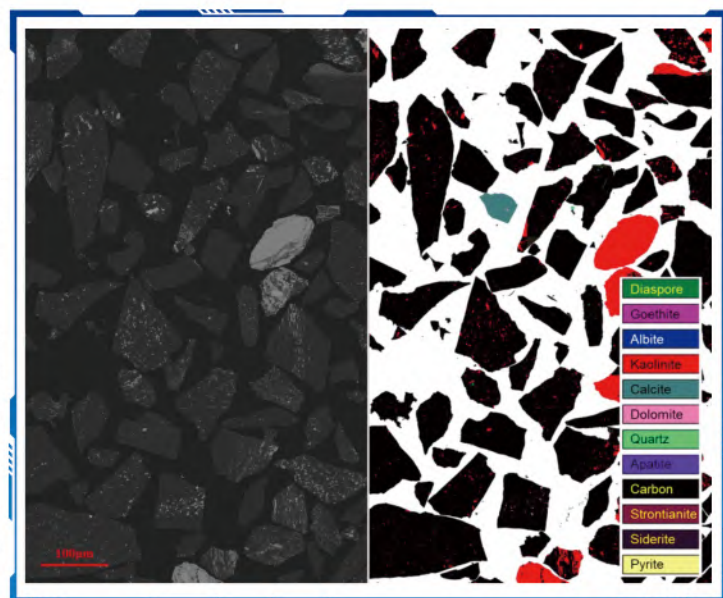


Fig.5 Mineral map of a coal sample by BPMA analysis.

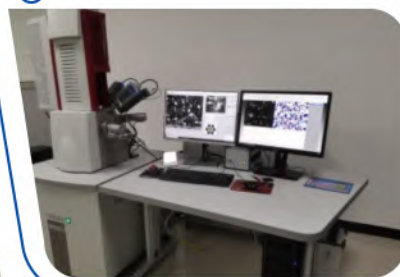
Main Users



Shandong Gold GOLD GROUP CO.LTD



Western Mining



Inner Mongolia University
of Science & Technology



University of Science
& Technology Beijing



State Key Laboratory of
Mineral Processing



State Key Laboratory of Process
Automation in Mining & Metallurgy

Installation Condition

Equipment Size	~2160mm(W) × 1010mm(D) × 1650mm(H), depends on SEM hardware size.
Room Size	Room > 3.0m(W) × 2.5m(D) × 2.3m(H); Door > 0.9m(W) × 1.9m(H). Air conditioner, Dehumidifier, & Vacuum cleaner are recommended.
Electrical Supplies	230 V ± 10% / 50 Hz, 2000VA ~ 3000 VA. UPS (SANTAK C6K/6KVA) is recommended.
Protective Ground	Independent ground wire, < 1 Ω
Temperature	18~24°C, ±2°C/24h, ±1°C/h.
Humidity	< 65%
Floor Vibration	< 5μm/s (less than 30 Hz) , < 10 μm/s (more than 30 Hz)
Magnetic Stray Field	synchronous feld < 300 nT; asynchronous feld < 100 nT
Compressed Air	6~7bar(87~102psi), Clean, Dry and Oil-free.
High Purity N₂	Highly pure nitrogen (>99.99%) with pressure reducing valve (adjustable to 0.02-0.03MPa) is strongly recommended.
Accessories	Sample preparation equipment, including but not limited to: polish-grinding machine (TMS-3), Carbon Coater (KYKY SBC-2-1), ultrasonic cleaner (JP-020S).