ZEISS Mineralogic
Your Solution for Automated Mineral Analysis
Maximize Your Recovery of Natural Resources

Characterize and achieve maximum recovery of resources: with ZEISS Mineralogic you use automated mineral analysis to identify and quantify minerals in real-time.

ZEISS Mineralogic is your geological investigation tool, answering a wide range of questions of your sample. From dedicated high throughput mineral liberation workflows to in-depth fundamental geoscientific investigations, the combination of image processing, standards-based quantitative EDS, image analysis and reporting toolkits can be configured to interrogate even the most challenging samples.

ZEISS Mineralogic combines a scanning electron microscope with one or more EDS detectors, a mineral analysis engine and the Mining software plug-in. Simply choose the ZEISS SEM platform that best suits your applications from conventional or field emission systems.

Tailor Your System to Analyze Any Mineral
Match mineral classification methods to your sample texture. For maximum accuracy, use the highly sensitive technique of standards-based quantitative EDS. For the fastest analysis speeds, choose BSD grayscale alone. Combine both techniques with grain size, shape and intra-granular porosity-based mineral classification to achieve textural quantification. Include element ratio rules to discriminate end members of a solid solution. Combining chemical and morphochemical classifications allows you to classify lithology to automatically categorize your particles, and identify and quantify ore types. High resolution imaging combined with a full suite of image processing functions gives you a powerful edge to solve previously impossible application challenges.

Simple Ore Body Characterization
Unknown ore bodies are now simple to characterize thanks to quantitative EDS. The stoichiometry of all unclassified minerals is measured and can be used to quickly classify unknown minerals. Simply return to the unknown grain at the click of a button and investigate further with the system’s full standalone EDX capability. Creating a mineral library to classify an unknown ore body now takes hours instead of weeks. Furthermore, mineral libraries can be copied to new instruments to avoid a significant overhead recreating instrument specific libraries. Trace elements can be quantified using uXRF, EPMA and LA-ICP-MS through a new seamless correlative workflow and assigned to mineral classes to report trace element assay measurements and take account of hydrated or lithium bearing minerals.

Count on High Throughput
ZEISS Mineralogic measures and classifies minerals in real-time. Once the sample run is complete, there’s no need for post processing. Quantification of the EDX spectra takes no time at all thanks to today’s computing technology. Measurement modes and stop criteria allow you to tailor your analysis speed. You can also reanalyze data sets retrospectively offline using modified mineral classification rules. You’ll achieve maximum automation and productivity with a 16-stub sample holder and a range of ZEISS SEMs. Choose between one and four energy dispersive spectrometers (EDS) with class leading detector solid angles. Producing dedicated reports has never been easier.

Copper ore particle containing pyrite (yellow) and chalcopyrite (red) lithologically classified as a composite sulfide particle. Courtesy of Esme Ryan, PhD., Rio Tinto, Australia

Residual copper slag particle from large Zambian copper smelter. Courtesy of Petrolab, UK

Copper ore particle containing pyrite (yellow) and chalcopyrite (red) lithologically classified as a composite sulfide particle. Courtesy of Esme Ryan, PhD., Rio Tinto, Australia

Analyze up to 16 metallurgical blocks in a single run with the 16 block holder
Your Insight into the Technology Behind It

**Image Processing**
With ZEISS Mineralogic you benefit from a unique suite of more than 60 algorithms for customized image processing. This gives you a particular advantage when tailoring your analysis to unique textures, materials and application questions. Set multiple BSD grayscale thresholds and windows to exclude potting media and analyze only high value target minerals. Avoiding unwanted regions and edge effects using image processing reduces your time to result while improving your data quality.

**Mapped Data Stitching**
When a particle is not fully contained within a field of view, stitching of the particles is required across multiple fields of view. The innovative ZEISS approach to data stitching enables recombination of particles to provide precise and accurate measurement of size and liberation. Simply enable mapped data stitching and ZEISS Mineralogic will automatically join boundary particles and ensure data integrity across the measurement of liberation, particle size, grain size, lithology and associations.
Your Insight into the Technology Behind It

Mineral Classifications

Standards-based Quantitative EDX
Measure the stoichiometry of each pixel and assign mineralogy independently of beam conditions using the most fundamental property of the mineral with the EDX detector energy and intensity calibrated to known standards.

Standardless Quantitative EDX
Measure the stoichiometry of each pixel and assign mineralogy independently of beam conditions with the energy of the EDX spectrum calibrated to a known peak.

Assigned Compositions
Import high precision, trace element data from an external data source and assign fixed elemental abundances to mineral definitions.

Element Ratios
Where minerals contain the same elements in different quantities, separate them using element ratio rules.

BSE Only
For high speed mineral classification, use the calibrated BSE detector to identify minerals at the speed and resolution of imaging.

Morphochemical and Lithological Classification
Use high resolution images of grains to create super-classes using size, shape, and intragranular porosity. Combine chemical and morpho-chemical classifications to create lithological classifications allowing the rapid categorization of particles and the identification and quantification of ore types.

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Number</th>
<th>Area %</th>
<th>Weight %</th>
<th>Carbonate Silicate</th>
<th>Carbonates Gangue</th>
<th>Clean Roanikite</th>
<th>Dirty Roanikite</th>
<th>Feldspars</th>
<th>Grouped Mica</th>
<th>Grouped</th>
<th>Roanikite</th>
<th>Sulphides</th>
<th>Others</th>
<th>Pore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosaic</td>
<td>64</td>
<td>4.33</td>
<td>4.01</td>
<td>3.03</td>
<td>2.53</td>
<td>93.07</td>
<td>0.52</td>
<td>0.00</td>
<td>0.58</td>
<td>0.26</td>
<td>0.00</td>
<td>0.00</td>
<td>2.87</td>
<td></td>
</tr>
<tr>
<td>Disseminated</td>
<td>3165</td>
<td>23.88</td>
<td>22.52</td>
<td>40.76</td>
<td>23.46</td>
<td>0.00</td>
<td>2.90</td>
<td>0.00</td>
<td>2.97</td>
<td>1.03</td>
<td>26.15</td>
<td>0.12</td>
<td>33.87</td>
<td></td>
</tr>
<tr>
<td>Gangue</td>
<td>11521</td>
<td>67.74</td>
<td>69.17</td>
<td>64.36</td>
<td>34.33</td>
<td>0.00</td>
<td>0.15</td>
<td>0.00</td>
<td>0.57</td>
<td>0.00</td>
<td>0.00</td>
<td>0.58</td>
<td>5.13</td>
<td></td>
</tr>
<tr>
<td>Remaining Particles</td>
<td>492</td>
<td>4.05</td>
<td>4.29</td>
<td>48.03</td>
<td>29.67</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.64</td>
<td>19.57</td>
<td>0.00</td>
<td>1.09</td>
<td>6.43</td>
<td></td>
</tr>
<tr>
<td>Sample</td>
<td>15242</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Quantification of different lithologies present in the sample.
Your Insight into the Technology Behind It

Analytical Measurement Modes

**Full Mapping**
Perform quantitative EDX mapping of a sample at a user defined spacing to build up a detailed map of your sample.

**Fast Scan**
Individual grains are identified and multiple spots are analyzed across the grain to provide a rapid average composition of the grain.

Spot Centroid
Individual grains are identified and their mineralogy assigned by an EDX analysis at the centre of the grain.

Line Scan
A quantitative EDX analysis is performed at a user defined spacing along a line through the center of a particle to build up a fast bulk composition of the sample.

Feature Scan
Individual grains are identified and their mineralogy assigned by quantitative EDX while the electron beam rasters over the grain.

Phase of Interest Search
Identify grains of interest through image processing and map them and any associated grains rapidly.

---

In Brief

The Advantages

The Applications

The System

Service

---

High resolution map of a PGE-rich podiform chromite prospect. Courtesy of Dr. Chris Brough and University of Cardiff, Wales

Example of mapped line scan mode showing quantitative EDX measurements across the center of each particle.

Montage image of ZEISS Mineralogic analysis of a gold-silver hosting base metal sulfide vein. Courtesy of John Spratt, Natural History Museum, UK
Your Insight into the Technology Behind It

View and Manage Your Results
Use ZEISS Mineralogic’s Explorer application to browse results of mineralogy, mineral associations, mineral partial exposed perimeter, elemental assay, lithology, and mineral liberation. Sort particles and grains, and view. Click on a particle of interest and the SEM will automatically drive to a live image of the particle. Automatically separate touching particles. Create large mineral maps and BSD grayscale montages and use mineral map stitching to generate large particle maps. Enjoy the convenience of modifying mineral classifications. Retrospectively re-analyze data offline increasing productivity. Quickly export data for further handling.

Create Reports Effortlessly
Save time with Mineralogic’s built-in reporter tool; predefined reports can be filled automatically, while the SEM is still acquiring data. Alternatively, you can generate reports from previously acquired data at your convenience. Use drag and drop functionality to produce new report templates, that are ready for export to Microsoft® applications.

Handle, Filter and Query Data
Merge replicate data and report as a single fraction. Merge fractions to reconstitute the unsieved material results. Mineralogic’s comprehensive filtering and data querying engine allows you to probe sample data like never before.
# Tailored Precisely to Your Applications

## The Applications

### Industry: Mining

- **Feed**
  - Ore evaluation
  - Grade determination
  - Feed forward analysis

- **Concentrate**
  - Optimization of grinding and beneficiation processes
  - Grade determination
  - Refinery penalty/bonus element quantification

- **Tailings**
  - Environmental control
  - Quality assurance and control
  - Process optimization

### Industry: Geoscience Research

- **Geochronology**
  - Age determination of rock samples using zircons

- **Planetary Geology**
  - Fundamental geological process determination

- **Ore deposit research**
  - Economic geology

- **Mineralogy**
  - Understand mineral composition

---

### ZEISS Mineralogic Offers

- Modal analysis
- Assay
- Chemical distribution
- Textural quantification
- Efflorescence
- Bulk mineralogy
- Elemental assay
- Textural quantification
- Detailed quantitative mineralogy
- Mineral associations
- Textural quantification
- Precise chemical analysis
- Chemical differentiation during crystal growth
- Image segmentation, processing and mineral mapping
- Correlation to optical microscopy
- Correlation to electron microscopy imaging (BSE, SE, CL)
- Correlation to X-ray microscopy*

* Requires ZEISS Atlas 5
ZEISS Mineralogic at Work

Mining Feasibility

High resolution mineral map. Ni-Cu ore, Fraser Mine, Sudbury. Courtesy: University of Leicester, UK

Mineral Processing

Analysis of metals with ZEISS Mineralogic. Gold mineralization in association with sulfide veining, in particular with sphalerite. Courtesy of Prof. Simon Dominy, Curtin University, Australia

Mineral processing plant automated daily metallurgical reports. Courtesy of iMIN Solutions.
ZEISS Mineralogic at Work

Geoscience

Applied morphochemical classification to assess differences in major element chemistry between two distinct magnetite textures. Courtesy of Prof. David A. Holwell, Applied Environmental Geology, University of Leicester, U.K.

Atlas-correlation of thin section photomicrographs and Mineralogic data to help classify magnetite textures. Courtesy of Prof. David A. Holwell, Applied Environmental Geology, University of Leicester, U.K.

Mapping Ca and Mn zonation in Bluechist garnets.

Mineralogic scan of Scottish Lamprophyres showing feldspathic inclusions with myrmekite exsolution of quartz in a mixed feldspathic (plagioclase, albite and orthoclase) matrix.

Peralkaline Granite, Northern Quebec, Canada, containing rare earth elements, including a fluorite vein that crosscuts the sample and zoned zircons.

Fully quantify elements to allow for both mineral identification and major element geochemistry at once. This sample, comprising clinochlore and chamosite, breaks down to Mg (15.3%), Al (9.1%), Fe (11.7%), Si (14.2%), O (48.4%).
Expand Your Possibilities

Microscopy Solutions for Natural Resources
ZEISS offers you the industry’s widest range of imaging solutions for natural resources. Choose from light, electron, X-ray and ion microscopes with an imaging range from centimetres to nanometres. Use multiple technologies for imaging and correlate your data to gain a deeper understanding of your samples.

Choose between focused ion beam and X-ray microscopy for imaging of volumes with voxel resolution as small as 5 nm.

The most advanced technology for the highest quality data.
Expand Your Possibilities

Correlative Image Viewing with ZEISS Atlas 5
With Atlas 5 you can compare and correlate data from any ZEISS microscope system. Combine images from the same region of interest, acquired with optical, electron, ion and X-ray microscopes. Atlas 5 is your disruptive technology for correlative data interaction in mining and geoscience.

Correlate the Following Image Types
- Entire thin sections imaged with the Axio Scan.Z1 slide scanner
- Reflected and transmitted polarized images from a light microscope such as Axio Imager 2
- Secondary electron, backscatter and cathodoluminescence images from a scanning electron microscope such as EVO, Sigma, and GeminiSEM.
- Mineral maps from a petrological analyzer such as Mineralogic
- 3D datacubes from an X-ray microscope such as Xradia Versa and Xradia Ultra
- 3D datacubes from a FIB-SEM such as Crossbeam 340, 540 and 550
Expand Your Possibilities

**Multiphase Automated Software**

With ZEISS Multiphase software you can automatically segment and quantify optical microscopy images. Compatible with the full range of ZEISS materials microscopes, ZEISS Multiphase easily quantifies sulfide mineralogy and provides an edge for fast and simple analysis. Benefit from mineral discrimination through optical properties of minerals with ZEISS Multiphase. Use ZEN Intellesis machine learning-based segmentation to enhance and expand your results.

Example image showing the multiphase process.
Original reflected light image on left, processed image on right.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrite</td>
<td>1.42</td>
<td>2.92</td>
<td>1.57</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>9.02</td>
<td>10.69</td>
<td>9.07</td>
</tr>
<tr>
<td>Bornite</td>
<td>12.14</td>
<td>13.47</td>
<td>13.74</td>
</tr>
<tr>
<td>Secondary CuS</td>
<td>0.91</td>
<td>0.66</td>
<td>1.14</td>
</tr>
</tbody>
</table>

**Area % of Copper Mineralogy**
Expand Your Possibilities

**Fully Integrated EDX, WDX and µ-XRF**

Benefit from integration into a single software package and combine EDX and WDX data for maximum flexibility. Spatial data correlation is automatically guaranteed.

ZEISS Mineralogic includes a full version of the Bruker Esprit software as standard. This allows the system to be used for standalone SEM-EDX work, imaging and automated mineralogy.

Upgrade your SEM with WDX or µXRF and experience a completely integrated EDX-WDX-µXRF analytical SEM.

WDX extends your analytical detection limit to 10 ppm and allows precise assigned mineral compositions to be inserted into Mineralogic for probe-quality assay measurements.

µXRF provides rapid bulk elemental quantification and high sensitivity, particularly of heavy elements, down to 10 ppm. SEM – µXRF removes the need for a standalone uXRF system.
Expand Your Possibilities

Raman RISE Microscopy
Enhance your automated mineralogy system with Raman vibrational spectroscopy to achieve a correlated Raman-automated mineralogy system.

Raman spectroscopy distinguishes minerals based on their vibrational spectrum. It is able to identify minerals with identical chemical composition, but differing crystal structure such as rutile and anatase (both TiO₂).

ZEISS Mineralogic and WiTec’s RISE Raman system are in use in mineral research laboratories around the world answering the most challenging applications questions concerning Earth and the solar system.

Iron mineralogy – (A) In the SEM image a piece of hematite (Fe₂O₃) shows some structural characteristics. (B) Hematite and goethite (FeO(OH)) in several crystal orientations were identified from their Raman spectra. Crystal forms of hematite are depicted in red, green, orange and pink, those of goethite in light blue and cyan. From the spectra, a Raman image was generated. (C) Correlation of Raman and SEM data resulted in the RISE image.

Abalone shell – (A) RISE image of a polished cross-section reveals the layered structure of the nacre (mother-of-pearl). It consists of aragonite, a crystal form of calcium carbonate. (B) Raman spectra can enable the differentiation of crystal orientations (blue / red) revealing the anisotropy of the aragonite phase.
Expand Your Possibilities

**Correlation to LA-ICP-MS**
ZEISS Mineralogic includes a correlative workflow between the automated mineralogy system and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). ZEISS and ESI have collaborated to provide a seamless automated workflow between the SEM and laser ablation system which incorporates a common correlative sample holder. Simply select your ICP-MS system of choice and experience trace element detection levels with complete confidence in the location of your laser spot.

Take the output of the LA-ICP-MS and insert trace element concentrations of minerals directly into ZEISS Mineralogic to automatically report trace element assay.

Applications include indicator mineral searching for mineral exploration, zircon dating for geochronology, and quantification of refractory gold in deportment studies.

*For further information, scan this QR code to download our new correlative white paper using LA-ICP-MS*
Your Flexible Choice of Components

ZEISS Mineralogic combines a scanning electron microscope with one or more EDS detectors and a mineral analysis engine – all controlled and operated from a single user interface. You can use all standard sample types, including stubs, geological slides and core cuttings. Choose the ZEISS SEM platform which best suits your applications: conventional or field emission systems.

**ZEISS EVO for 24/7 Ore Process Control**

EVO is the industry standard platform for automated mineralogy and is in operation worldwide in mineral processing laboratories. EVO’s column isolation valve allows fast sample transfer and chamber pump down, making it the ideal SEM for 24/7 ore processing. Choose between three chamber sizes – 10, 15 or 25 – to get the right system for your application. Use EVO in variable pressure mode for easy analysis of uncoated samples, shortening your time to result. Add Atlas 5 to correlate data with optical and X-ray microscopy.

**ZEISS Sigma 300 for High Throughput Analysis**

Sigma is a Schottky thermal emitter which combines a high brightness source with high stability improving your time to result. By exploiting Sigma’s exceptional imaging capabilities, you can distinguish minerals of similar average atomic weight by grayscale alone (0.07 atomic mass unit resolution). Thanks to the unique Gemini lens design, the Sigma family leads the field in terms of solid angle for maximum sample throughput. Add Atlas 5 to correlate data with optical and X-ray microscopy.

**ZEISS MinSCAN for Mine Site Operational Mineralogy**

ZEISS MinSCAN is the world’s first ruggedized mine site SEM. Capable of providing high throughput, pseudo real time actionable information to troubleshoot and monitor mineral processing plants, MinSCAN is designed to improve the mine’s bottom line. MinSCAN can be deployed at the mine site to provide results within 24 hours of sampling with up to four EDX detectors.
Benefit from the optimized performance of your microscope system with services from ZEISS – now and for years to come.

Because the ZEISS microscope system is one of your most important tools, we make sure it is always ready to perform. What’s more, we’ll see to it that you are employing all the options that get the best from your microscope. You can choose from a range of service products, each delivered by highly qualified ZEISS specialists who will support you long beyond the purchase of your system. Our aim is to enable you to experience those special moments that inspire your work.

**Repair. Maintain. Optimize.**
Attain maximum uptime with your microscope. A ZEISS Protect Service Agreement lets you budget for operating costs, all the while reducing costly downtime and achieving the best results through the improved performance of your system. Choose from service agreements designed to give you a range of options and control levels. We’ll work with you to select the service program that addresses your system needs and usage requirements, in line with your organization’s standard practices.

Our service on-demand also brings you distinct advantages. ZEISS service staff will analyze issues at hand and resolve them – whether using remote maintenance software or working on site.

**Enhance Your Microscope System.**
Your ZEISS microscope system is designed for a variety of updates: open interfaces allow you to maintain a high technological level at all times. As a result you’ll work more efficiently now, while extending the productive lifetime of your microscope as new update possibilities come on stream.