EDS

High speed differentiation of mineral phases of similar BSE intensity with AMICS

Application Note # EDS-16

Introduction

The identification of minerals based on BSE signal segmentation can be problematic seeing that some minerals have very similar BSE intensities. The **A**dvanced **M**ineral **I**dentification and **C**haracterization **S**ystem (AMICS) software is a powerful tool to overcome such difficulties.

AMICS utilizes advanced imaging and analysis software capabilities and can be linked to selected scanning electron microscopes (SEM) and Bruker's QUANTAX energy dispersive X-ray spectrometry (EDS) system.

One of the core features of the software is the innovative image analysis to segment particles ensuring accurate mineral boundary identification and particle separation.

AMICS uses the latest computer vision techniques to segment BSE images, using two adjustable interdependent parameters to:

- control the sensitivity to gray level variation
- control the size of the segmented region
- detect very subtle variations in the image, caused by mineral change or image condition change.

By controlling the size of the segmented region, the system can simulate X-ray maps (such as GXMAP in MLA) to detect minerals of very similar BSE gray levels (with reduced number of X-ray points). This modern method can handle large images and is reasonably fast.

Using the AMICS advanced segmentation, typical problematic minerals such as Quartz-Albite, Chalcopyrite- Pentlandite and silicates have been investigated.

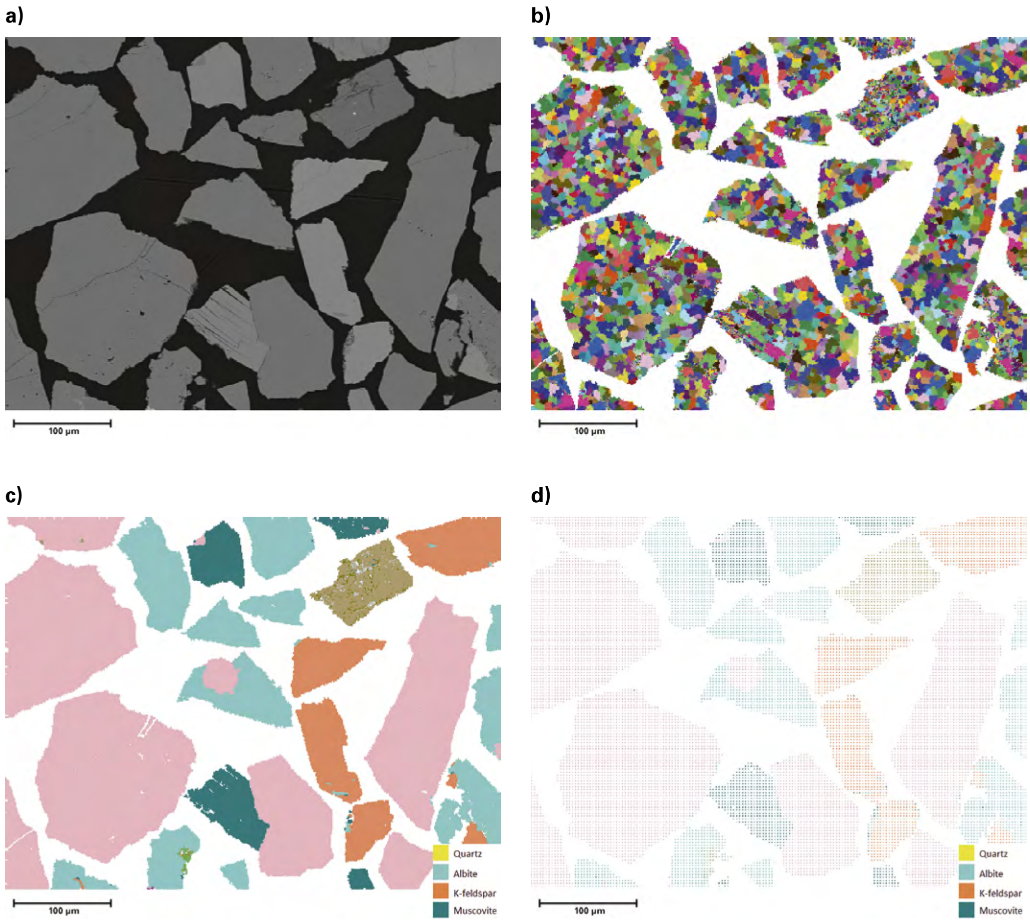


Figure 1 – Quartz-Albite
BSE image of the sample showing little contrast (a), particle segmentation image showing the result of segmentation of fine variations in BSE intensity (b), resulting mineral map showing Quartz, Albite, K-feldspar and Muscovite after Particle mode analysis (c), mineral map showing Quartz, Albite, K-feldspar and Muscovite after Mapping mode analysis with 5 µm step size (d).

Method

To perform the measurement in an automated manner and achieve reliable results, a SEM with a backscattered electron (BSE) detector was used in combination with the QUANTAX EDS system and the AMICS software.

- SEM: Hitachi S3500
- HV: 20 kV
- Beam current: 90,000 cps on copper using EDS
- Electron detector: Solid state BSE
- Magnification: 140x
- EDS detector: XFlash® 6 | 10 EDS detector, 126 eV at Mn Kα

Particle Mode

In Particle mode, the BSE image is processed and segmented using the advanced image processing. Following the segmentation each area is analyzed by X-ray allowing each segment to be identified and classified independently. This mode performs detailed mapping to provide output data such as association, liberation and size.

Mapping Mode

In Mapping mode, the BSE image is processed only to remove the mounting medium (background). Each particle is then analyzed by a grid of X-ray points. Each X-rayed point within the particle is identified and classified. This mode is a fast method to obtain bulk mineralogy and calculated assay, but has limitations in data output, i.e. no liberation or size.

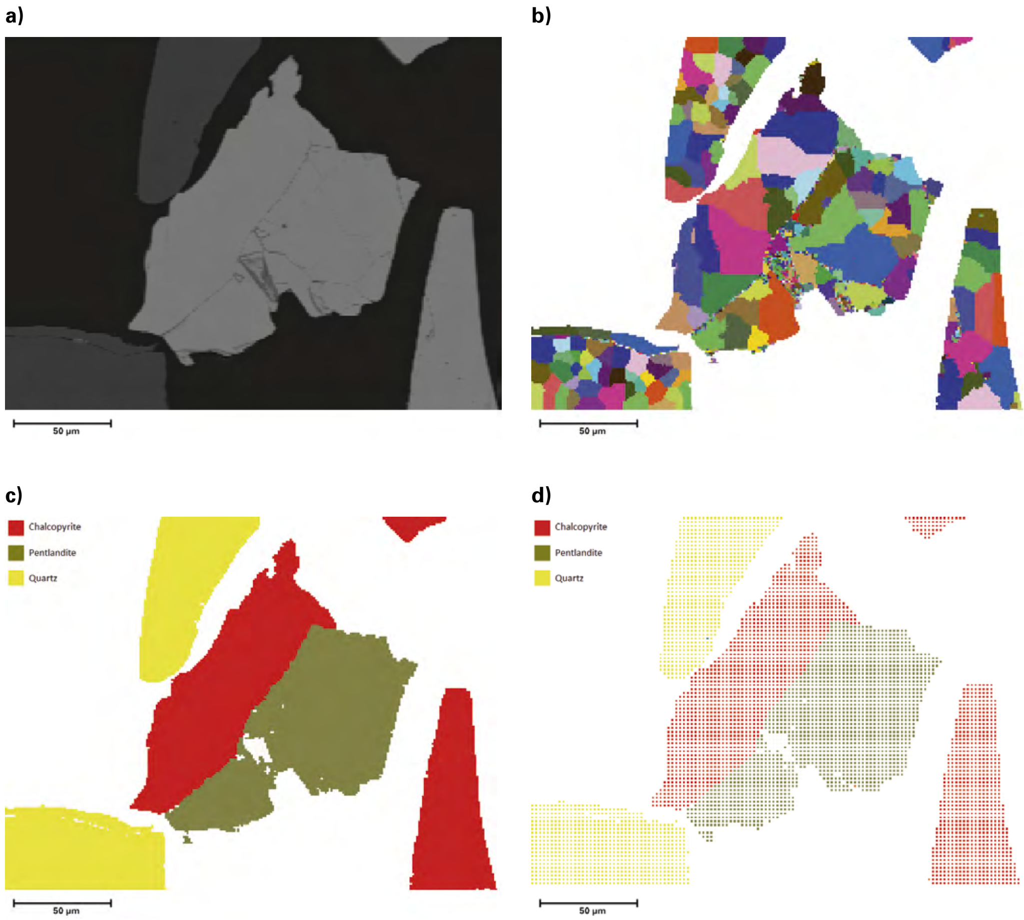


Figure 2 – Chalcopyrite-Pentlandite
BSE image (a), segmentation image (b), resulting mineral maps showing Chalcopyrite, Pentlandite and Quartz in Particle mode (c) and Mapping mode (d).

Samples

The investigated samples are:

1) Ground particles from a mineral processing plant, mounted in a 30 mm diameter epoxy block, polished and carbon-coated. The mineral types analyzed include particles containing Quartz-Albite or Chalcopyrite-Pentlandite.

2) Polished thin sections composed of silicate minerals.

Quarz-Albite

Observing the BSE image in Figure 1a, which was acquired with an image resolution of 1.46 µm/pixel, 2–3 phases can be distinguished. However, the advanced particle segmentation using the Particle mode shows many more variations (Figure 1b). These variations occur due to signal variations produced by beam instability or detector noise, as well as changes in the mineral content or average atomic number.

After X-ray analysis, identification and classification of each segment, the resulting particle mineral map in Figure 1c shows four major mineral phases, plus a multi-phase particle.

Performing the analysis with the Mapping mode, the results confirm that the AMICS segmentation in Particle mode had successfully distinguish Quartz and Albite as shown in Figure 1d.

Chalcopyrite-Pentlandite

As previously performed, the Particle mode was applied to the Chalcopyrite-Pentlandite sample. The BSE image was acquired with an image resolution of 1.84 µm/pixel, and then processed and segmented, followed by X-ray analysis, mineral identification and classification.

Figure 2 shows the BSE image (a) and the segmentation by small variations within each particle (b). Again each segment is individually analyzed to provide a sound identification and classification of the three mineral phases Quartz, Chalcopyrite and Pentlandite (c). The mapping results in Figure 2d confirm that the AMICS segmentation successfully distinguished Chalcopyrite and Pentlandite.

Figure 3 shows additional examples with the mineral phases Chalcopyrite, Pentlandite and Pyrrhotite.

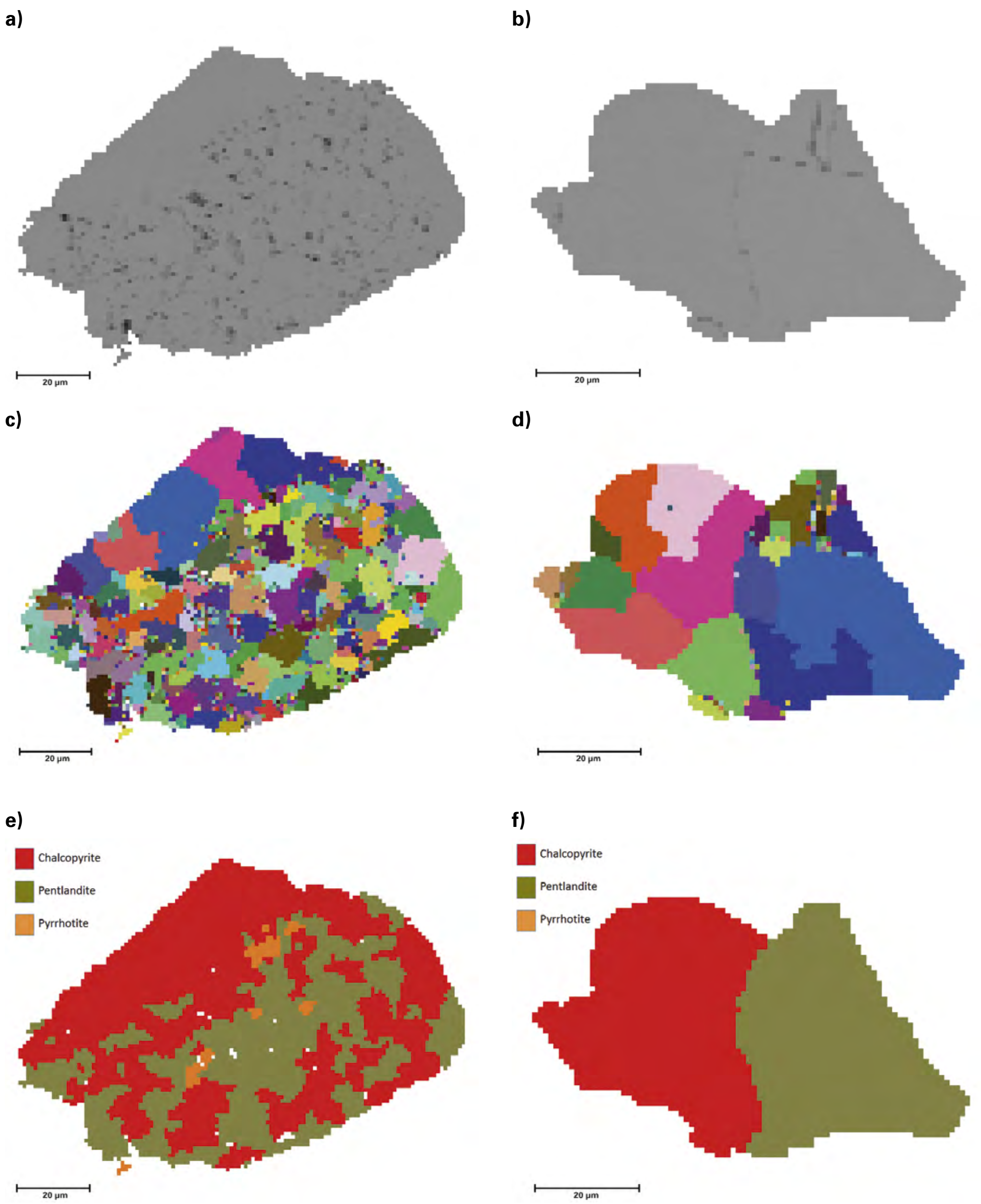


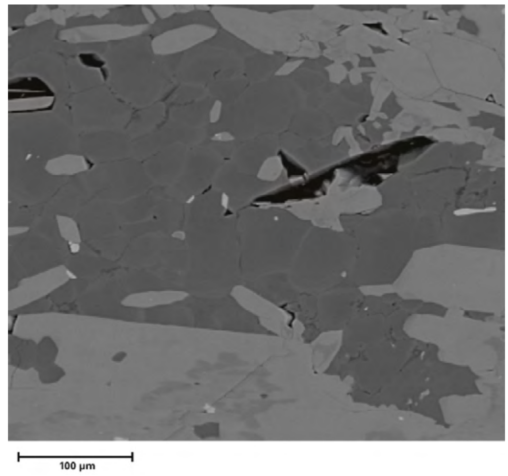
Figure 3 – Chalcopyrite-Pentlandite
BSE images (a, b), segmentation images (c, d) and mineral maps using the Particle mode (e, f) for two different particles in the sample.

Silicate minerals in a polished thin section

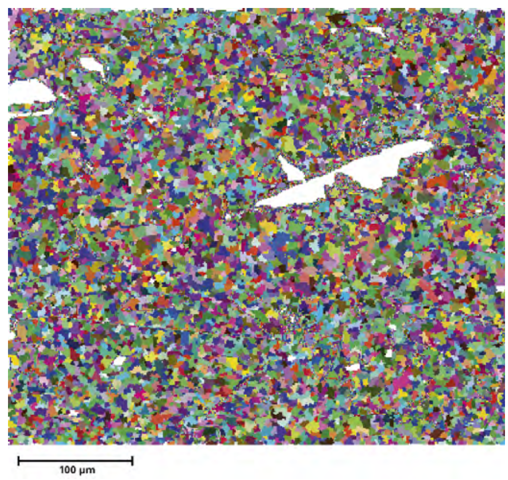
The examples in Figures 4 and 5 demonstrate the differentiation of silicates such as Quartz and Feldspar or Pyroxene and Amphibole in solid rock sections. Figure 4 shows the measurement of a single frame at 0.71 µm/pixel that illustrates the change in the Plagioclase composition across the sample.

Figure 5 shows the measurement of 12 frames with an image resolution of 3.3 µm/pixel, resulting in a total measurement time of 9 minutes 42 seconds. It demonstrates the ability to detect numerous phases not clearly distinguishable by simple BSE analysis.

a)



b)



c)

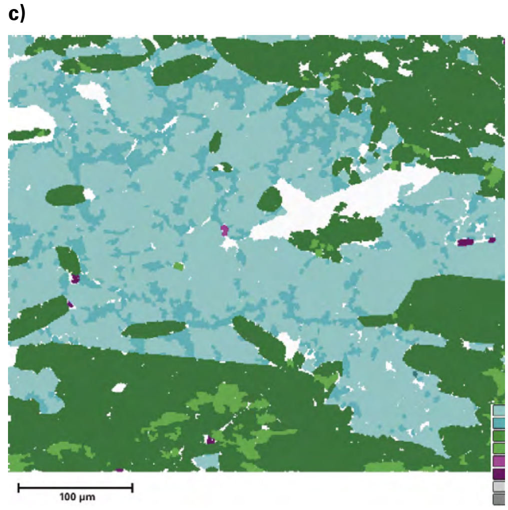


Figure 4 – Thin section of a silicate mineral
BSE image (a), segmentation image (b) and resulting mineral maps after Particle mode (c) of a silicate containing thin section. A single frame was measured at 0.71 µm/pixel.

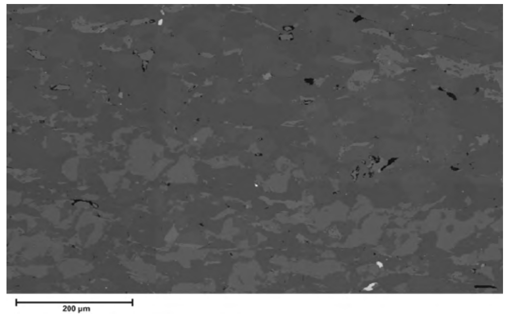
Conclusion

Minerals with similar BSE intensities such as Quartz-Albite and Chalcopyrite-Pentlandite can be effectively distinguished with AMICS's unique advanced segmentation in Particle mode.

Likewise, silicate minerals often have very similar BSE intensities but phases such as Quartz, Albite and different Plagioclase minerals can be reliable differentiated with AMICS's advanced segmentation technology.

Using the AMICS software, the measurement of solid samples such as polished thin sections can be achieved within a reasonable time and with seamless joining of image frames.

a)



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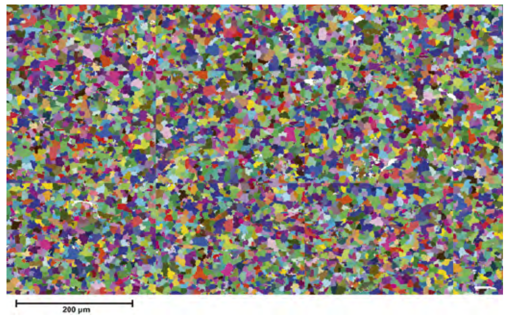

c)

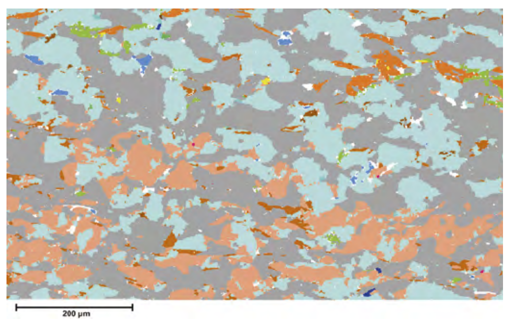

Figure 5 – Silicate mineral
BSE image (a), segmentation image (b) and resulting mineral maps after Particle mode (c) of silicate minerals. 12 image frames were measured at 3.3 µm/pixel.

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