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Separation of Hard to Distinguish Phases in Automated Feature Analysis

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Automated feature analysis in the SEM is a powerful technique which is widely applied across many applications. The technique relies on having a method for determining where the features to be analyzed are. This could be a case of separating features from the mounting medium or from other features, which may be a different phase but which sit adjacent to or touch the feature of interest. In many scenarios this task is successfully carried out using a backscattered electron (BSE) image – taking advantage of the phase density contrast in the images to separate the phases. Figure 1 shows this scenario.

In some cases the BSE image is not suitable for separating phases. This could be because the two phases which sit next to each other have a very similar density despite having different compositions with the implication that there is very little BSE contrast between them – the white phase in Figure 2 is a clear example of this. Adjusting the microscope contrast and brightness controls may help but frequently this approach is insufficient. A related scenario occurs when the background is complex with some grey levels overlapping those of the feature of interest. In such cases, the human eye can identify the feature but it is very difficult for an automated algorithm to do so. In this case it is impossible to tell just from grey level thresholding where one feature ends and another one begins. As such, the morphology measured is for the combined outline including both of the features and is wrong for both. Furthermore, the EDS acquisition is obtained from both features and the recorded composition is a mix of the two features. This situation is clearly not ideal.

Here, we show a new method which utilizes phase mapping in the context of automated particle analysis to identify features without using the BSE image. The method instead identifies them by their chemistry.

When element mapping is performed with an EDS system, a series of maps are acquired, one for each of the detected elements. When phases are present, there is a relationship between these maps where certain regions show consistent ratios of elements. These regions are phases. This technology has previously been discussed here as AutoPhaseMap. The latest development of present interest is the implementation of the AutoPhaseMap algorithm for the identification of features by automated analysis.

In order to address the two scenarios discussed above, two approaches are available. Where there are complex backgrounds or there is insufficient contrast in the entire image, the whole field of view is mapped and features are identified and extracted from this map. Where features are clearly visible but multiple phases exist within one grey level threshold, only the regions within those thresholds are mapped. This offers a significant time saving as the remaining features are analyzed by the "normal" BSE image based method.

Once the relevant maps have been acquired, phases are extracted from them and constructed into features. Morphology is measured and each feature is quantified using the same rules as are applied during "normal" feature analysis. All features are then classified. As the same rules of quantification and classification are used as in a “normal” run, it is valid to compare features which have been acquired with the different methods. This process can be applied to a large area analysis to enable FeaturePhase mapping over complete samples.

Figure 3 shows the results of phase analysis on the white phases from Figure 2. The central particle clearly shows the presence of multiple phases which could not have been identified from the BSE image in Figure 2. The remaining grains which do not sit in the white threshold are analyzed by a “normal” particle analysis routine and have a single spectrum acquired from each feature. As such, the completed analysis with all features classified is a combination of both phase and “normal” analyses.

Figure 4 shows an example of whole field FeaturePhase analysis. Here, the aim is to analyze a rough region of biotite with islands of K-feldspar – analyzing the two phases separately. Due to the very rough texture of the biotite it is not possible to satisfactorily separate the two phases with BSE. It can clearly be seen that the automated separation of these phases across the whole field becomes possible using the FeaturePhase algorithm.

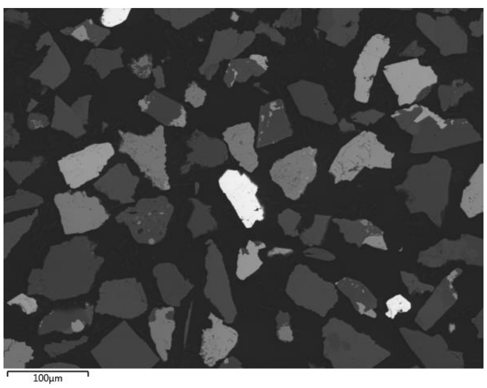

Figure 1. An Ideal Contrast/Brightness Setup where it is easy to Separate Features in a BSE image

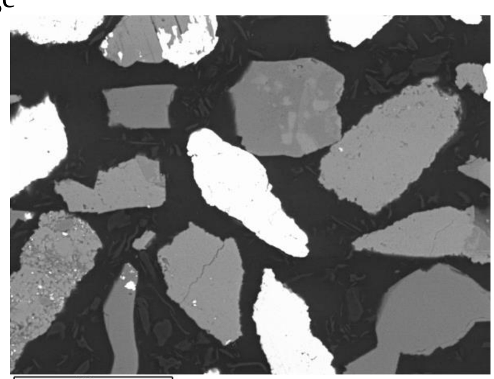

Figure 2. Less Ideal Contrast/Brightness Settings – Many Phases have the Same Grey Level (white)

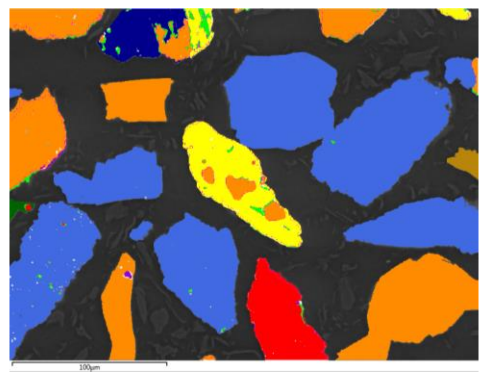

Figure 3. FeaturePhase Analysis of Feature in the White Threshold & “Normal” Acquisition for all other features

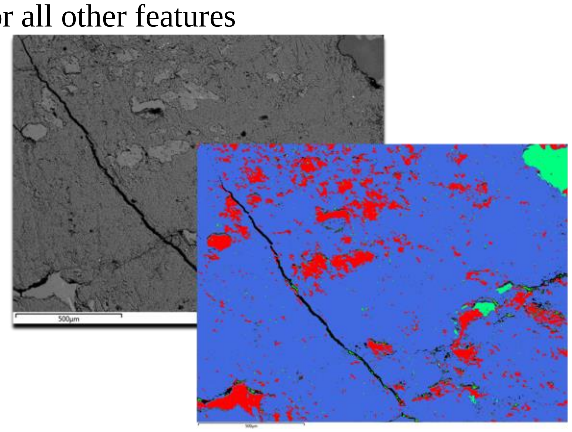

Figure 4. Dual Images Showing Automated Phase Identification over a Full Field Classified image shows K-feldspar (red) & biotite (blue).

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