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Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Automated mineralogy based on energy dispersive X-ray fluorescence microscopy (μ-EDXRF) applied to plutonic rock thin sections in comparison to Mineral Liberation Analyser" *by* Wilhelm Nikonow and Dieter Rammlmair

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Dear referee,

thank you for your time and effort reviewing our manuscript. We have considered your helpful remarks and included the necessary additional information in the manuscript as follows:

1. Why use the algorithm, Spectral Angle Mapper, in classification? Please provide a bit explanation

Response: The following information and literature reference has been added to chapter 2.4: "The classification algorithm allocates a mineral name to each pixel in the element distribution map according to a prior defined database of mineral spectra (endmember collection). It calculates the spectral similarity of two spectra, which is described by the angle between the vectors of both spectra. The angle of the spectral similarity can have values from 0 to $\pi/2$ in radians (Masoumi et al., 2017). The vectors are in an n-dimensional space, where n is the number of bands (here: element lines). SAM was developed for classification of hyperspectral images and is most widely applied in context with mineralogical classification (Van der Meer and De Jong, 2003). Girouard et al. (2004)."

2. I don't really understand Table 4, error matrix. Please explain more about 'error matrix'.

Response: The following explanation regarding the error matrix was added to the introduction: "Assessment of 2D classification data has been applied and discussed widely among remote sensing scientists. In most cases, hyperspectral images are evaluated by comparison to reference images (Foody, 2002), which are supposed to have true classification values (ground truth images) e.g. through manual control. Each pixel of the reference image is compared to the new classification and the numbers of pixels assigned to each class are entered into an error matrix (or confusion matrix); the reference pixels are listed in columns and the new data in rows. The central diagonal represents the pixels that were assigned to the correct class, all others have been assigned to a different class. The classification's overall accuracy can be calculated by dividing the sum of the correctly classified pixels (central diagonal) by the total pixel number (Congalton, 1991)."

3. One of advances of the method u-EDXRF is to use less efforts (time) than other

methods. My understanding is it uses larger step size according to Table 1. Please confirm.

Response: The effort for a measurement is a combination of sample preparation, measurement preparation and the actual measurement. The μ-EDXRF is non-destructive and needs almost no sample preparation, since it only needs a flat sample surface. In our work, polished thin sections were used only for a good comparison to MLA. Also, the operational effort of a μ-EDXRF is only a fraction of the effort to operate a SEM+MLA (laboratory, equipment, skilled operator, polishing, carbon coating and measurement).

With MLA we applied two different measurement modes: (1) XBSE uses grey levels to differentiate single grains and performs only one analysis per identified grain. That means there is no regular measurement grid, which can save a lot of measuring time, if minerals have enough contrast to be distinguished. Because the grey level differentiation did not work on sample 484 due to similar average atomic numbers of minerals, we applied (2) GXMAP, which is a continuous mapping with a given step size. This increased the measurement time to about 40 h, which is almost 7 times the μ-EDXRF measurement.

While the SEM uses an electron beam at 25 kV, μ-EDXRF uses an x-ray beam at 50 kV for excitation. The high excitation voltage allows the μ-EDXRF to measure K-lines of elements that exceed the SEM range. Well known examples are Zr or Mo with K-lines above 15 keV and overlapping L-Lines with the K-lines of P and S, which can be easily distinguished by μ-EDXRF.

4. Fig.4 Clarify only marker colors of the legend on the figure are meaningful.

Response: We have added the color key and legend of all phases to the figure, even if this small section does not show some minerals like titanite. This is necessary because Fig.3 uses the same color code and it would consume a lot of space to include a color key in Fig.3.

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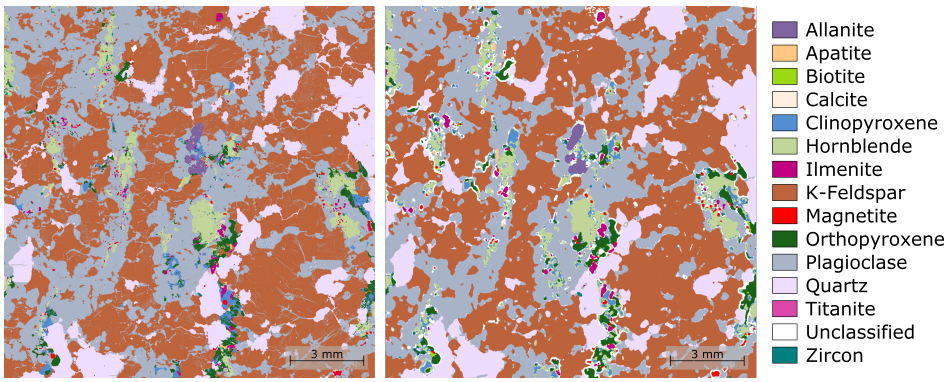

Fig. 1. New Fig. 4; Detailed view of a section in the upper right corner of sample 342: Mineral distribution map from MLA (left) and ENVI (right).