

Appendix A- C.I.A.C.C. routine considerations

SI from “Digital image analysis on cathodoluminescence microscopy images for ancient ceramic classification. Methods, applications, and perspectives.” Odelli et al

The DIA routine named CIACC proposed in the present study was assessed after numerous test and image acquisitions on different ceramic typologies and under different experimental conditions.

To evaluate and set the better acquisition parameters and extract reliable quantitative data, the images were acquired on samples sectioned in thin and thick section, turning voltage and exposure times. Lightness mean (i.e., average luminosity of the image) Lightness Standard Deviation (i.e., describing how much the samples is non-uniform in CL response) and Lightness Median (i.e., the median luminosity among image pixels value) were thus considered and evaluated.

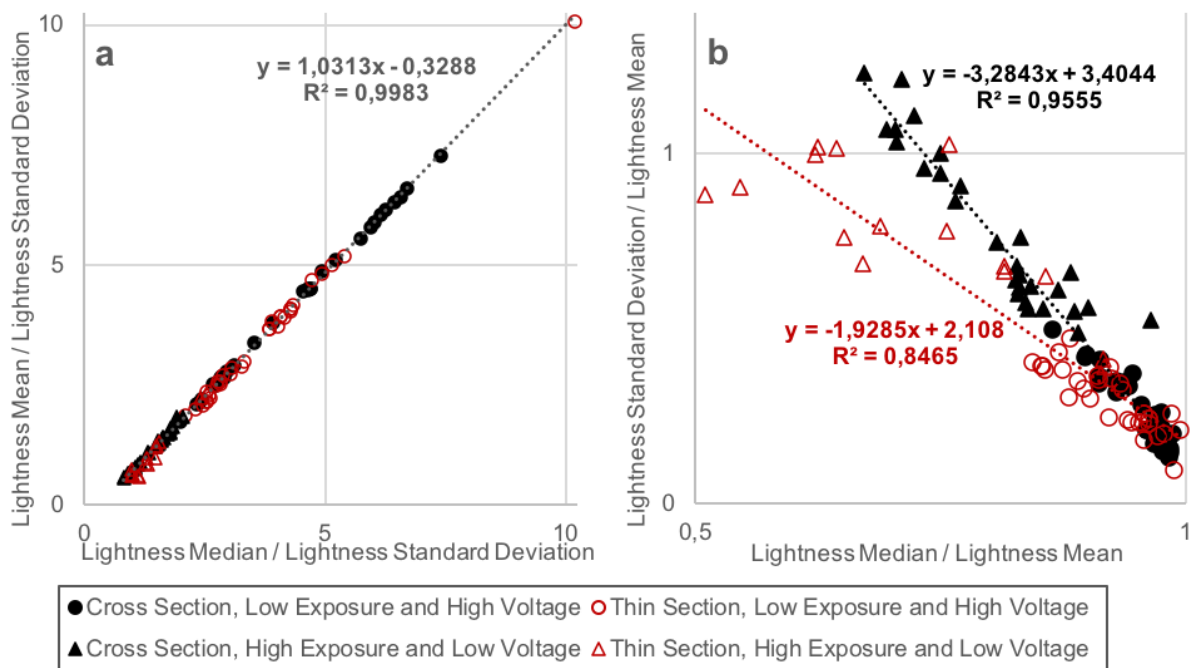


Figure A1. Graph representing image analysis lightness results. Markers have been divided with different colour and shape: the colouring divides the different samples preparation, red for thin section and black for thick section; shape divides the different acquisition parameter, triangular markers for images acquired from high exposure and low voltage, instead circular markers for image acquired from low exposure and high voltage. (a) Mean of the lightness normalized to its standard deviation are represented in ordinate axis, and lightness median normalized to the standard deviation are represented in the abscissa axis. The trend of all samples is highlighted by the trend line described by their equations and determination coefficients. (b) Standard deviations of the lightness normalized to its mean are represented in ordinate axis, and lightness median normalized to the lightness mean are represented in the abscissa axis. Thin sections (red) and thick sections (black) trends are highlighted by trend line described by their equations and determination coefficients (each having the same colour of the respective sample preparation).

Lightness Standard Deviation is strictly related to the homogeneity of the illuminated samples; in fact, low lightness St.Dev. corresponds to samples homogenous in composition and texture, otherwise high lightness St.Dev. values describe samples characterized by numerous components differently responding to CL. When lightness St.Dev. is used to normalize lightness mean and lightness median parameters, values from testing images show a linear trend, with lower values for acquisition at low voltage conditions and higher values for acquisition at high voltage conditions, claiming that lightness median and mean parameters are mainly imprinted by set up conditions, while St.Dev. by the nature of the

samples. Standard Deviation and Median normalized to the Lightness Mean are plotted in Figure A1(b). This normalization brings the results to the same lighting conditions, thus highlighting the response of the samples to CL. Triangular markers (describing images collected at high exposure and low voltage conditions) tend to stretch the differences in CL response of the different components of the ceramic sample (mineral grains and matrix) compared to circular markers (describing images collected at low exposure and high voltage conditions). The formers show a StdDev / Mean ratio higher than the latter, indicating a greater difference between the responses of the matrix and the inclusions, while the latter have a lower Median/Mean ratio indicative of a less intense response of the fractions less susceptible to CL. From that it is possible to infer that, for the purpose of image acquisition, CL setup is important and in particular it is convenient to use a low voltage and high exposure time. However, it is suggested not to exceed too much these analysis conditions to avoid saturation problems (Fig. A2).

Furthermore, further consideration can be provided regarding samples sectioned as thin or thick sections; in fact, it seems that a different surface treatment gives back a different CL response (see full vs empty triangles in Figure A1(b)). In thin sections, StdDev/Mean turns in a Median/Mean ratio variation higher compared to thick section; in fact, the intense CL response of mineral grains respect to clay paste/matrix determines higher values in StdDev/Mean ratio and lower values in Median/Mean ratio. Therefore, working on a thin section better enhances the contribute of mineral grains, while working on a thick section more information from the matrix can be obtained.

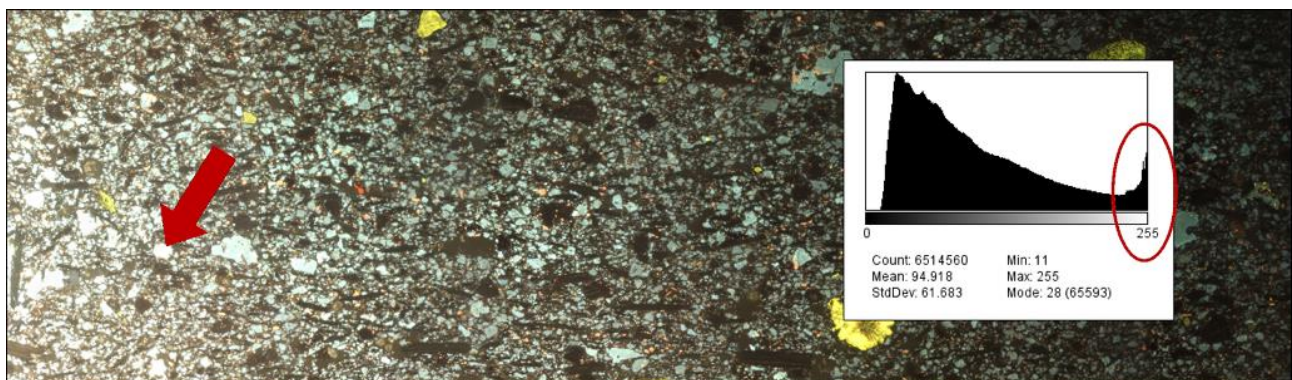


Figure A2. Picture showing the inhomogeneous electron beam distribution and saturation problems highlighted by the red arrow on the picture and the red oval on the image spectrum.

Brightness correction has been designed to make the images suitable for the image analysis, simulating the effect of an electron beam homogeneously distributed. Of course, the pre-processing has not to alter the images nature. Mean, standard deviation and median lightness parameters have been considered and plotted in Figure A3 before vs after brightness correction. The graphs show that samples resemble a linear trend, demonstrating that the images are not randomly altered, although for each image correction parameters (Gaussian filter and minimum of the brightness) are individually calculated and applied for the brightness correction. Furthermore, there are no anomalies from the linear trend, except for standard deviation. In fact, images collected by CL on thin sections at high exposure and low voltage conditions tend to deviate from the linear trend with a R^2 lower than other samples. This deviation is attributable to saturation issue. In fact, saturation of image can occur when too long acquisition times are applied; furthermore, when acquiring images on thin sections, the CL response of mineral grains on matrix is particularly stressed possible determining signal saturation.

Overall, by appropriately managing acquisition parameters to avoid saturation effects, the brightness correction seems a valid method to pre-process images before image analysis, not altering the nature of images even considering an expected standard deviation.

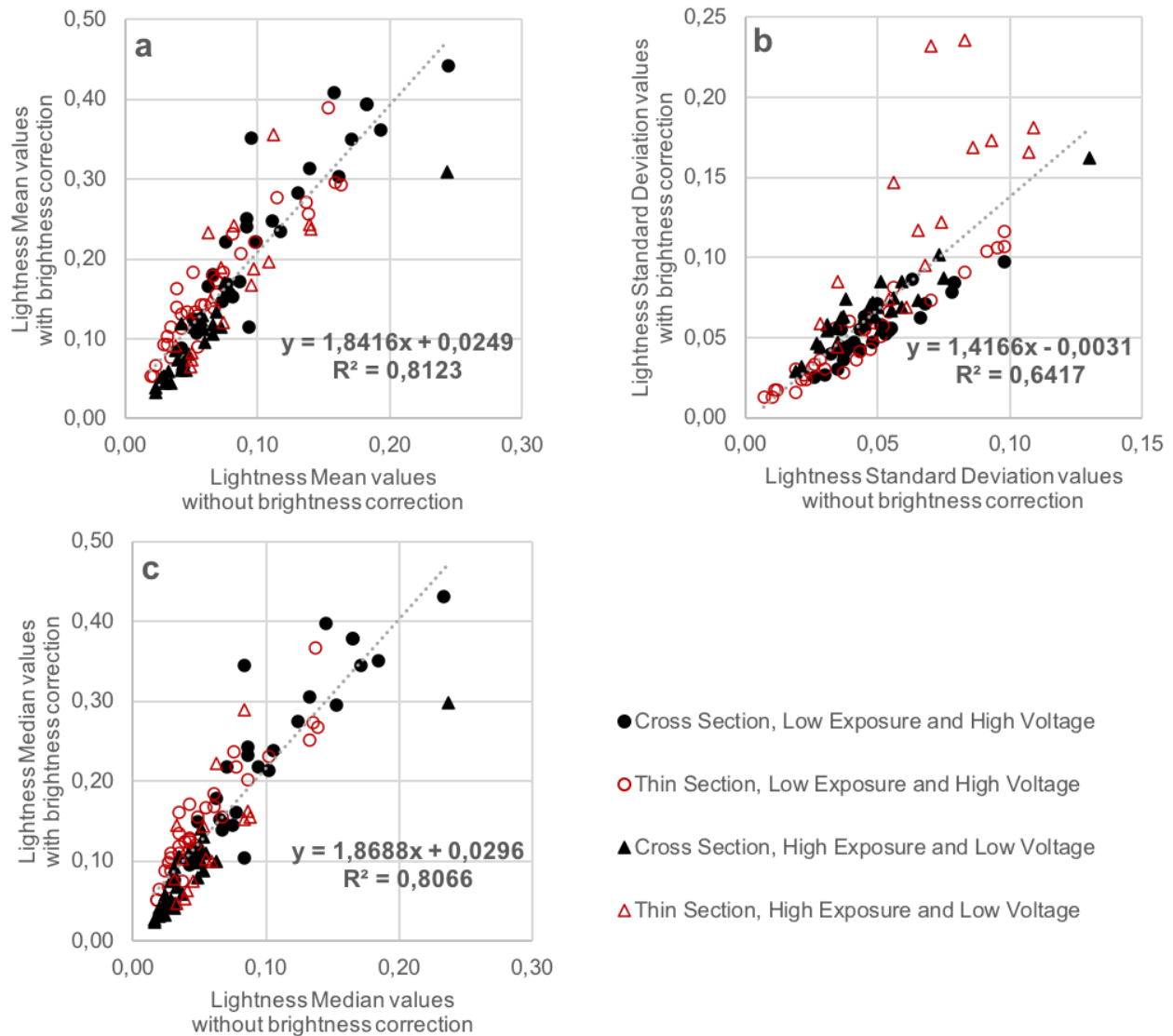


Figure A3. Graphs representing the lightness correction effect. Lightness values obtained by image analysis with brightness correction are represented in the ordinate axes, instead lightness values obtained by image analysis without brightness correction are represented in the abscissa axes. In each graph a different lightness parameter is plotted (a) mean, (b) standard deviation and (c) median. The marker's trend is highlighted thanks to the trend line described by its equation and determination coefficient.