Multiradial Imaging in Optical Ore Microscopy

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Introduction

Ore microscopy is essential in understanding the formation of the ore body and in forecasting any ore dressing problem that might occur in the plant. Experienced mineralogists rely on reflected light microscopy in both plane polarised and non-polarised conditions. Although, back-scattered electron microscopy and EDX mapping has been very much in favour in the recent years, it is obvious that the capabilities of quantitative optical imaging have been underestimated.

Materials and methods

Opaque minerals reflect variable amounts of light as a function of the wavelength and therefore appear coloured to the human eye. This property is not always discriminative. In the case of anisometric crystal structures, the dispersion of plane polarised light is an additional criterion used by microscopists to better determine the nature of the mineral.
An Olympus BX 60 microscope fitted with a rotating polariser (incident light beam) and a rotating analyser (reflected light beam) has been used for this study. Instead of rotating the sample stage, a synchronised rotation of the polarisers has been developed. This allows for taking pictures of multiple polarising positions (multiradial imaging) without having to rotate the pictures in memory. A PCO Sensicam with Peltier cooling and variable exposure conditions has been used for taking high-resolution pictures.

Multiradial Imaging

Fig. 1 displays a series of three images taken for different polarising directions on a unique scene. For sake of reasonable exposure times, the polariser and analyser are slightly decrossed (± 85°). The image contains an assemblage of magnetite (Fe_3O_4) and ilmenite ($FeO.TiO_2$) . This last phase hosts minute inclusion of hematite (Fe_2O_3). Supervised Fisher Linear Likelihood classification on colour images is unefficient to separate these minerals. The same classification of multispectral images (438nm, 489nm, 591nm, 692nm channels) allows for perfect classification of magnetite and ilmenite but misclassifies most hematite (anisotropic) inclusions into magnetite (isotropic). Additional information gained from the multiradial information achieves an almost perfect classification of all three minerals.

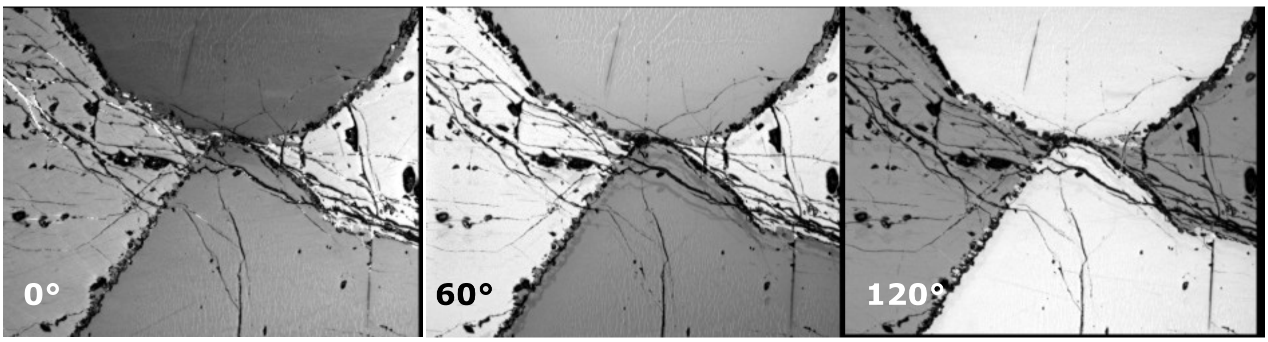

Fig. 1 Ilmenite and Magnetite grains seen under three angular positions of crossed polars.

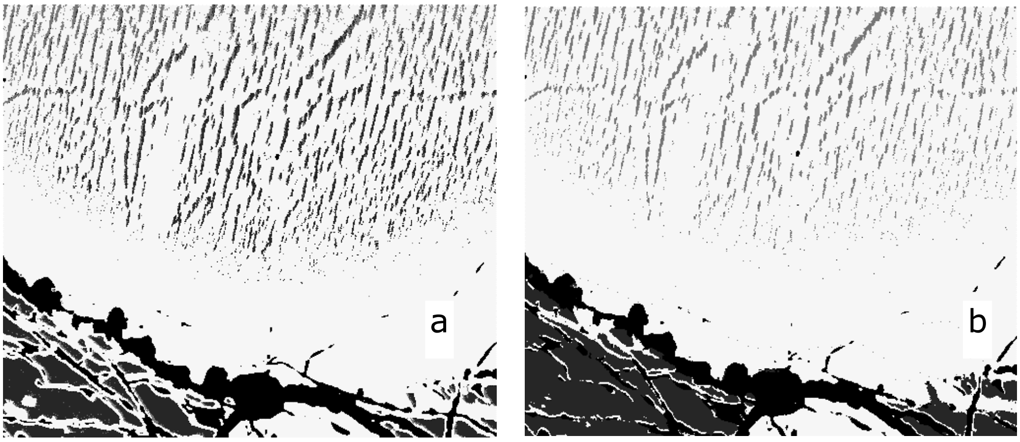

Fig. 2 a) Fisher Linear Likelihood classification of the four bands multispectral image.
b) Classification using identical algorithm and training sets but with two additional multiradial images.

Perspectives

Multiradial reflected light imaging justifies further developments in terms of hardware (e.g. motorised polariser rotation (Fueten,1997)) and software (e.g. automatic spatial registration of the set of images). Alternative microscope designs should be looked for in order to eliminate or reduce artefacts generated by the semi-reflective mirror.

Nevertheless, multimodal imaging (multispectral + multiradial) is a promising field for efficient optical image analysis in ore microscopy.

References

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