

# Application of X-ray mapping to the interpretation of silicate mineral assemblages

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## INTRODUCTION

Metamorphism, magmatism and the formation of ore deposits imply the often sequential (re)crystallization of mineral phases. Hence, an intensive study of the textural-mineralogical development of the rocks greatly increases the understanding of the processes involved in their formation, such as growth and dissolution. The invention of the electron probe microanalyzer (EPMA) in 1951 by Raymond Castaing entailed a significant contribution to the chemical characterization of the mineral phases. One of the EPMA applications that should be not underestimated is the X-ray intensity mapping of areas of interest in thin sections. This technique allows obtaining two-dimensional spatial distribution maps of several measured elements in their textural context that, together with the development of appropriate software, allows deciphering the processes involved in their formation and evolution. In this contribution we show X-ray maps applied to silicate mineral assemblages. To do so, we study different lithologies and illustrate the importance of this technique in the textural-chemical analysis of minerals.

## METHODS

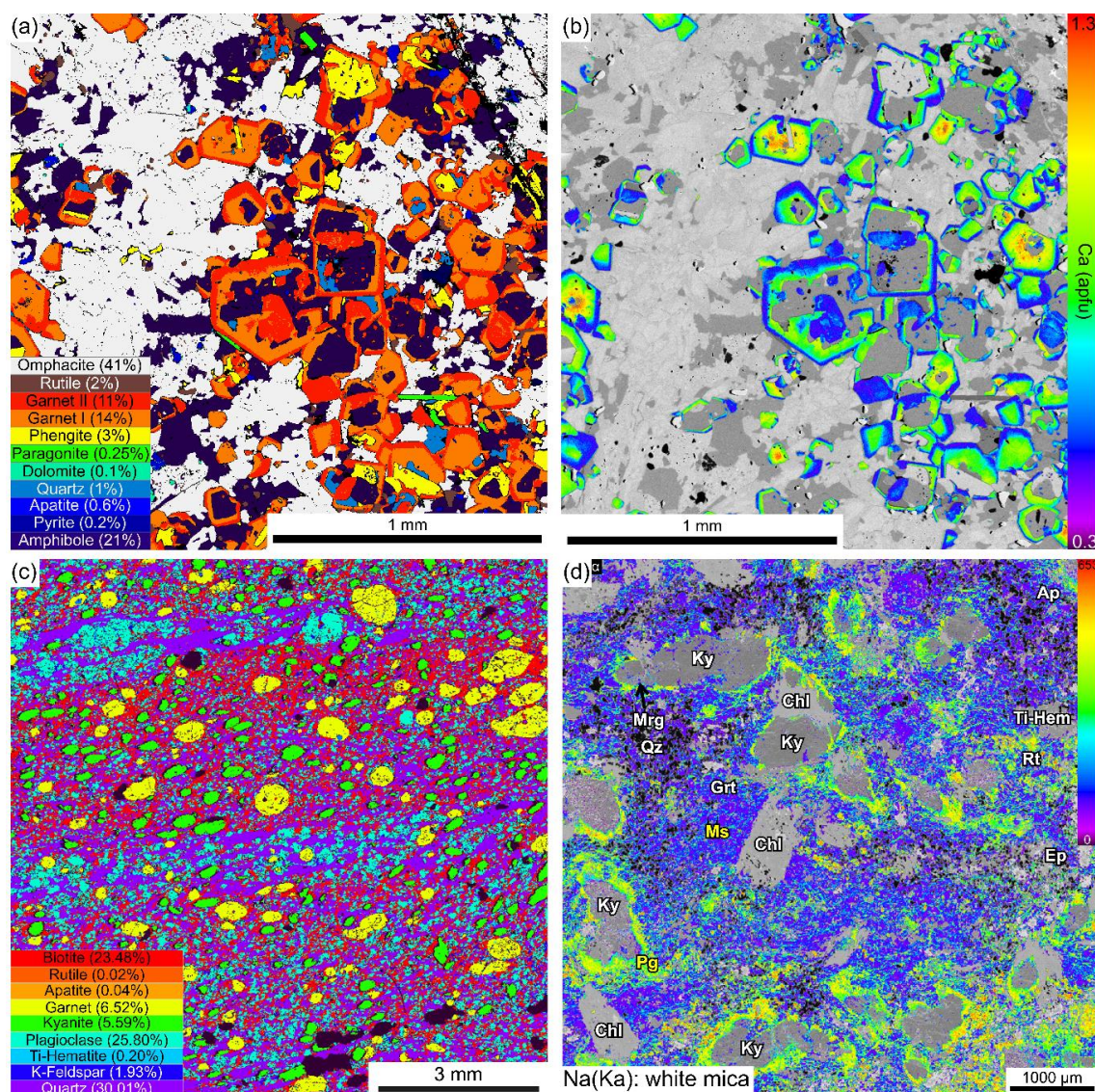
Elemental X-ray intensity maps were acquired with a JEOL Superprobe JXA-8900M from the CNME of the Complutense University (Madrid, Spain) in two raster sessions to analyze all the elements of interest (Si, Ti, Al, Fe, Mg, Mn, Ca, Na, K). In contrast with the spot analysis, high beam currents are used to avoid protracted mapping time. The operation conditions of the superprobe were 300 nA beam current, 20 kV accelerating voltage and 20 ms dwell time, with a pixel size ranging between 2 and 14  $\mu\text{m}$ , depending on the sample. The X-ray maps were processed with software DWImager (Torres-Roldán & García-Casco, unpublished), which transforms the raw X-ray data provided by the superprobe (in the form of matrix data for each element) into elemental map images. X-ray maps were masked with this software to avoid voids and polish defects and to show selected minerals to better observe the textural-chemical characteristics of the minerals or mineral assemblages. Moreover, isolation of the phases in the images through the manipulation of several histograms at a time (i.e. phases maps) is used to obtain the location and abundance of the minerals.

Quantification of the X-ray maps is performed as in García-Casco (2007). Internal standards correspond to point analysis of the target mineral within the scanned area obtained after the acquisition and careful study of the X-ray maps. The quantification follows the Bence & Albee (1968) scheme and the  $\alpha$ -factor table of Kato (2005). Each pixel in the quantified maps is a mineral analysis expressed in a color-coded scale of atoms per formula unit. X-ray maps are set on top of a grey-scale base-layer that offers the basic textural relations of the scanned area calculated with the expression:  $\Sigma(\text{counts})_i^*A_i$ , where A is atomic number, and  $i$  is Si, Ti, Al, Fe, Mn, Mg, Ca, Na and K.

## APPLICATIONS AND CONCLUSIONS

Figure 1 shows the results of the X-ray mapping of an intermediate-T eclogite, a high-P migmatitic paragneiss and a high-P metahyaloclastite (Novo-Fernández, 2022). In these maps, the compositional variations of the phases as well as their textural relationships can be clearly identified through the corresponding phase maps and compositional maps. X-ray mapping can be applied in a large variety of mineralogical, metamorphic and magmatic problems and allows assessing the compositional relationships at high-resolution in two-dimensions. Hence, this technique can be

key when the objective is the chemical characterization of the silicate mineral assemblages and their and textural-mineral development.



**Figure 1.** a) Phases map showing modal proportion and distribution of the minerals of an intermediate-T eclogite. b) X-Ray map of Ca proportion (apfu) in garnet in the same sample. c) Phases map of a high-P migmatitic paragneiss. d) X-ray map of Na (Ka) distribution in white mica of a high-P metahyaloclastite (Novo-Fernández, 2022).

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