xCLent - Application Note

Refractory brick analysis

Refractory materials are commonly used in high-temperature industrial processes because of their high-temperature mechanical properties. These materials are well suited to examination by cathodoluminescence microscopy because a number of the constituent phases exhibit strong cathodoluminescence. For example, periclase (MgO), corundum (Al_2O_3), and spinel ($MgAl_2O_4$) structures have all been examined using cathodoluminescence microscopy. The cathodoluminescent active refractory phases can be quickly detected, their distributions examined and the extent of elemental substitutions within particular grains can be readily assessed using x-rays. The assessment of both alumina-chrome and chrome-free refractory materials which are used to line smelting, converting and refining furnaces have been studied using optical microscopy, backscattered electron imaging and cathodoluminescence to determine the depth of penetration of slag into the refractory brick.

Images collected on an alumina-chrome refractory that has been exposed to a number of thermal temperature cycles and exhibits significant chemical changes across the section investigated. The refractory brick was exposed to Fe and slag in the furnace and elemental changes, including penetration of Fe into the brick can be observed on the right-hand side of Figure 1(a). The associated cathodoluminescence map, Figure 1(b), reveals subtle changes occurring through a number of the larger grains due to the thermal cycling. Cathodoluminescence spectra, Figure 2, taken from selected areas on both the core and rim of the grain show different spectral responses. By selecting areas on the core and rim, averaging the x-ray data from the pixels in each area, a difference in Mg concentration is observed between the core and rim. The Mg concentration in the rim is of order two hundred parts per million higher than the core. This illustrates the sensitivity of the cathodoluminescence signal to trace element variations, and the importance of having a combined x-ray and cathodoluminescence data set.

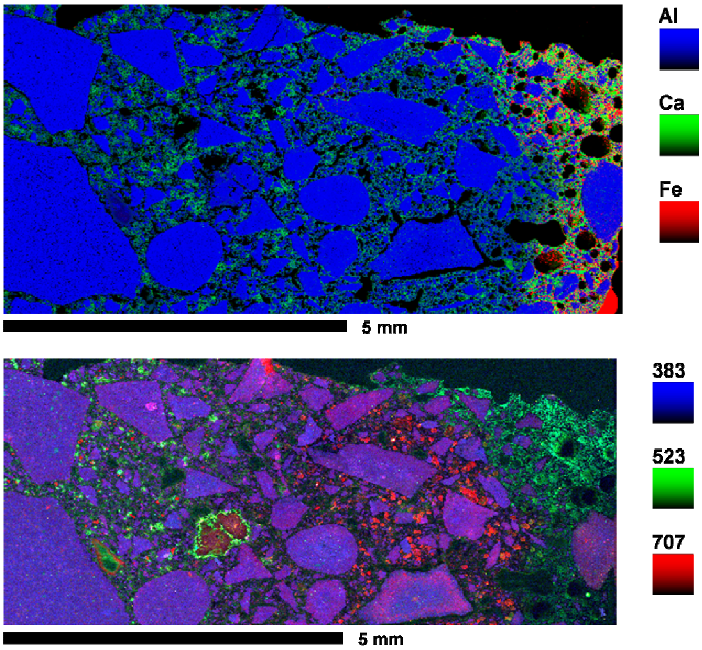

Figure 1.

a. Elemental map of an alumina-chrome refractory brick exposed to a number of thermal cycles showing the penetration of Fe from the right-hand-side into the brick.

b. Three discrete cathodoluminescence wavelengths. The colour change in the large grains is examined by selecting two areas, highlighted, and examining the spectra.

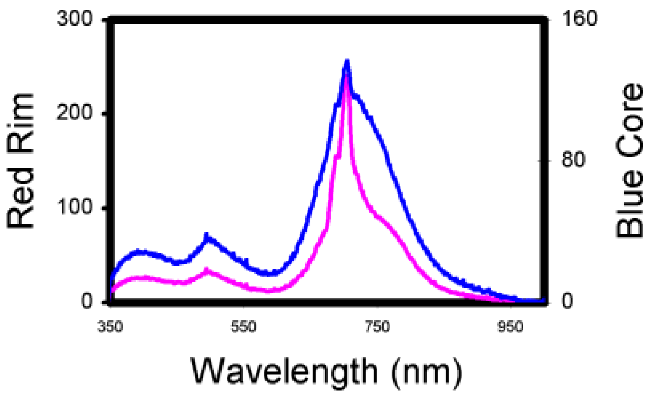

Figure 2.

Selected area cathodoluminescence spectra taken from the core and rim of the grain in figure 1. The difference in the spectra is related to varying Mg concentrations across the grain.

Reference:

1. MacRae *et al.* Microscopy Research and technique 67:271-277 (2005) Hyperspectral mapping - combining cathodoluminescence and X-ray collection in an Electron Microprobe.