Combined Hyperspectral Soft X-ray and Hyperspectral Cathodoluminescence study of an Ureilite

Wilson, N.[1], MacRae, C.[1], Torpy, A.[1] and Tomkins, A.[2]

[1] CSIRO Mineral Resources, Australia, [2] 2School of Earth Atmosphere and Environment, Monash University, Australia

Ureilites are a rare type of stony meteorite that contain carbonaceous materials such as diamond and graphite[1]. The diamonds can be examined using hyperspectral cathodoluminescnce (CL) in the electron probe microanalyser (EPMA) which in the past has proved a useful technique to map nitrogen-vacancy defects and correlate these with elemental data[2]. CL spectra from diamonds are sensitive to defect structure, with more than a thousand spectral lines reported from over a 100 centres[3]. The fixed grating spectrometers used for cathodoluminescence (CL) collection on EPMAs have improved in specifications, now offering higher resolution gratings and changeable entrance apertures, leading to enhanced spectral resolution. The resolution of CL emission peak may be further improved by cooling the sample to liquid nitrogen (LN) temperatures to reduce thermal broadening.

More recently, soft x-ray emission spectrometers (SXES) [4] have become available for both the EPMA and SEM. The SXES has lowered the limit of detectable x-rays, to as low as Mg-L (49 eV), and provides a high energy resolution, which can be as small as 99 meV for Mg L. This makes the SXES an ideal tool for examining peak shape and position changes that come about due to changes in the local chemical environment and can be easily observed for x-ray lines that are involved with bonding, such as the C KΦ#177; line. SXES spectra are collected in parallel using a CCD camera, and in our case were collected simultaneously with WDS, EDS and CL spectral data.

We have fitted a field-emission gun EPMA (JEOL 8530) with a LN stage, SXES detector, two SDD EDS detectors (Bruker XFLASH 6010) and a high resolution grating CL system [5,6]. The LN stage has the ability to move while at cryogenic temperature, so we can collect maps in both beam scan and stage scan. We have developed software to allow the simultaneous collection of the backscatter electron signal, WDS, EDS, SXES and CL spectral data.

A Ureilite (NWA3140) has been mapped at both room and LN temperatures, with an example of a LN stage map given in Fig 1a. Bonding effects on the Carbon Ka peak can be seen in Fig 1b, and the benefit of cooling to cryogenic temperatures in the LN cold stage can be seen in Fig. 1c.

References:

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[6]We acknowledge support from ARC - LE130100087

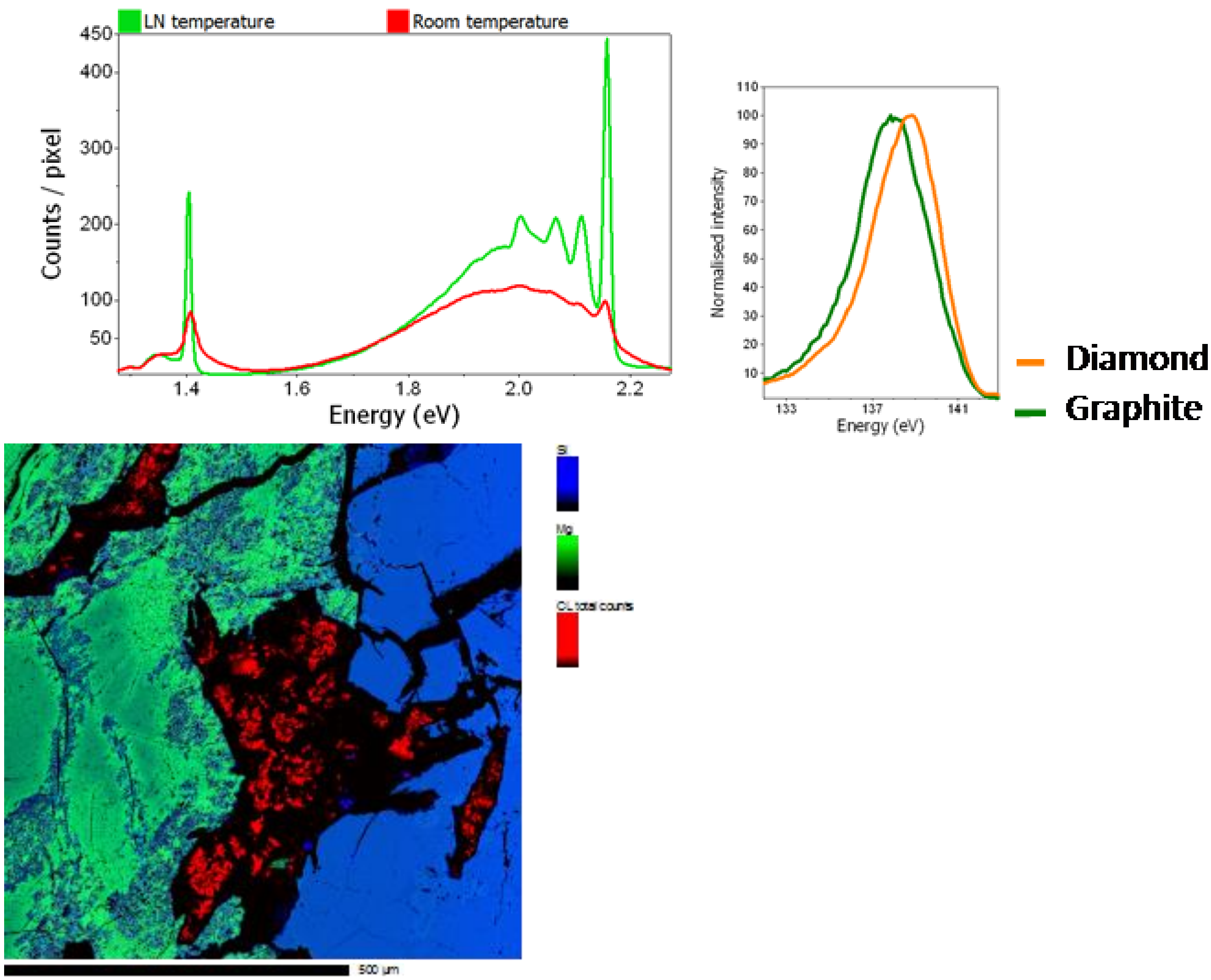

Figure 1. (a) Combined x-ray and CL map from a Ureilite sample with the bright red showing diamond inclusions in the Ureilitie. (b) SXES spectra from diamond and graphite regions (c) Comparison of cathodoluminescence spectra from the same diamond within the Ureilte collected at 294 K and 77K (LN temperature), with the spectrum collected at 77K showing a higher resolution and greater intensity.