

Synchrotron micro-X-ray fluorescence analysis of natural diamonds: First steps in identification of mineral inclusions in situ

**HUSIN SITEPU,^{1,*} MAYA G. KOPYLOVA,^{1,†} DAVID H. QUIRT,² JEFFREY N. CUTLER,³
AND THOMAS G. KOTZER³**

¹Department of Earth and Ocean Science, The University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada

²Saskatchewan Research Council, 15 Innovation Boulevard, Saskatoon, Saskatchewan S7N 2X8, Canada

³Canadian Light Source Inc., 101 Perimeter Road, Saskatoon, Saskatchewan S7N 0X4, Canada

ABSTRACT

Diamond inclusions are of particular research interest in mantle petrology and diamond exploration as they provide direct information about the chemical composition of upper and lower mantle and about the petrogenetic sources of diamonds in a given deposit. The objective of the present work is to develop semi-quantitative analytical tools for non-destructive in situ identification and characterization of mineral inclusions in diamonds using synchrotron micro-X-ray Fluorescence (μ SXRF) spectroscopy and micro-X-ray Absorption Near Edge Structure (μ XANES) spectroscopy at a focused spot size of 4 to 5 micrometers. The data were collected at the Pacific Northwest Consortium (PNC-CAT) 20-ID microprobe beamline at the Advanced Photon Source, located at the Argonne National Laboratory, and yielded the first high-resolution maps of Ti, Cr, Fe, Ni, Cu, and Zn for natural diamond grains, along with quantitative μ SXRF analysis of select chemical elements in exposed kimberlite indicator mineral grains. The distribution of diamond inclusions inside the natural diamond host, both visible and invisible using optical transmitted-light microscopy, can be mapped using synchrotron μ XRF analysis. Overall, the relative abundances of chemical elements determined by μ SXRF elemental analyses are broadly similar to their expected ratios in the mineral and therefore can be used to identify inclusions in diamonds in situ. Synchrotron μ XRF quantitative analysis provides accurate estimates of Cr contents of exposed polished minerals when calibrated using the concentration of Fe as a standard. Corresponding Cr K-edge μ XANES analyses on selected inclusions yield unique information regarding the formal oxidation state and local coordination of Cr.