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EPMA and SXES analyses on Impact quartz and its implication

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The identification of quartz polymorphs in meteorite impact structures has traditionally relied on thin-section observations, X-ray diffraction (XRD), and Raman spectroscopy. In contrast, surface analytical methods such as EPMA and SEM are limited to imaging, as their characteristic X-ray analysis distinguishes only elemental compositions and density differences, making polymorph discrimination difficult. Recently, the advent of Soft X-ray Emission Spectroscopy (SXES) has enabled laboratory-scale observation of Si $L_{2,3}$–M transitions, thereby allowing direct exploration of the electronic environment around silicon. This technique demonstrates potential applications ranging from the discrimination of silicate minerals to the identification of quartz polymorphs.

In this study, we present SXES patterns of Si $L_{2,3}$–M transitions in quartz, pyroxene, and olivine, together with their interpretations. EPMA and SXES mapping analyses were conducted on shocked quartz collected from the Hapcheon meteorite impact crater in South Korea. The electron beam conditions for SXES analysis were set at 2 kV, 50 nA, WD 11 mm, and 60 s, optimized with respect to the excitation energy of Si. Because the Si $L_{2,3}$–M transition pattern is affected by the seventh-order reinforcement interference of C Kα, non-conductive samples required thin C coatings or Pt/Au coatings. The SXES spectra show a gradual change in Si distribution patterns from quartz to olivine, reflecting the influence of corner-sharing oxygen connectivity on orbital electron density.

EPMA analysis of shocked quartz revealed a slight decrease (~0.3%) in total values between quartz and coesite, attributable to density differences among polymorphs, though the variation is not significant in quantitative terms. SXES patterns also exhibited subtle differences; while distinctions from glassy phases were difficult to resolve, quartz polymorphs could be relatively well discriminated. These results highlight the utility of SXES in complementing conventional methods for the exploration of quartz polymorphs formed under impact conditions.