Wilhemine copper mine, Spessart, Bavaria: A Kupferschiefer-related, hydrothermal mineralization

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The vein-type copper mineralization in the abandoned Wilhelmine copper mine at Sommerkahl is hosted by orthogneisses of the Spessart Crystalline Complex. These are covered by sedimentary rocks of Permo-Triassic age, including the stratabound base-metal mineralization of the Kupferschiefer. Ore textures in the sulfide veins testify to three stages of mineralization:

(i) An early stage is characterized by colloform textures, documented by spherical, garland-shaped or cockade-like aggregates of tennantite I, enargite I, pyrite I, chalcopyrite I, bornite I and digenite I.

(ii) During a subsequent recrystallization stage, these were overgrown by, or enclosed in, tennantite II, enargite II, bornite II, digenite II, pyrite II and chalcopyrite II. Fine-grained to submicroscopic digenite-bornite intergrowths, exsolved from an initial 1*a*-solid solution, contain up to 55 mole-% of bornite, indicating a minimum temperature of 175°C for this stage.

(iii) A late alteration stage led to the replacement of primary sulfides by yarrowite, spioncoppite and rare covellite, together with goethite.

The close spatial association of the vein-type Cu mineralization with the overlying Kupferschiefert suggests a genetic relationship. In situ sulfur isotope analyses of sulfide minerals yielded negative $\delta^{34}S$ values of –12.8 to –23.9 ‰ indicating a derivation from the Kupferschiefer, presumably by hydrothermal leaching. By contrast, we assume that the metals were derived from deep-seated sources, transported upwards by hydrothermal fluids and precipitated by thermochemical sulfate reduction, due to interaction with the Kupferschiefer. Formation of the sulfide ore veins is related to a hydrothermal activity in Middle Jurassic to Early Cretaceous times.

Micro-Raman and cathodoluminescence characterization of shocked quartz from impact craters

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Introduction

Evidence of shock metamorphism can be sufficiently proved by the existence of planar deformation features (PDFs) found in quartz. However, visual identification of the planar features under optical microscope should be unambiguous for clarifying PDFs. To characterize shock-induced planar microstructures such as PDFs in quartz from various impact craters, we used a combination of cathodoluminescence (CL) and micro-Raman spectroscopy with high sensitivity and high spatial resolution.

Samples and Methods

Quartz grains from Ries Crater, Barringer Meteor Crater, and Oikeyama Crater are employed for Raman and CL measurements. They were prepared as polished thin sections. PDFs are observed in several quartz grains under a petrographic microscope. Raman spectra were acquired with a confocal micro-Raman spectrometer at 20 mW using a Nd:YAG laser (532 nm) excitation system. CL imaging and spectral measurements were carried out on a SEM-CL (scanning electron microscope combined with a grating monochromator) with an accelerating voltage of 15 kV.

Results and Discussion

SEM-CL imaging of quartz grains from each crater shows non-luminescent or CL-dark lines related to PDFs, which can be clearly observed under polarized microscope. Raman spectra of shocked quartz from the Ries Crater exhibit a pronounced peak at around 459 cm^{-1}, which can be assigned to Si-O-Si streching vibration, whereas unshocked quartz has a sharp and intense peak at 464 cm^{-1}. This frequency shift may arise by a distortion of the structural cofiguration (i.e., formation of high density silica) caused by shock-metamorphism. The Raman imaging of shocked quartz from each impact crater shows a stripe pattern suggesting layers comprised of high and low crystalline parts corresponding to the optical image of PDFs. Our results show that shock-induced amorphization might effect an alteration of electronic transition processes in defect centers that are correlated to CL emission.