American Mineralogist, Volume 90, pages 132–142, 2005

Quantitative evaluation of attenuation contrast of X-ray computed tomography images using monochromatized beams

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Abstract

A quantitative relation between the linear attenuation coefficient (LAC) obtained by Synchrotron Radiation X-ray computed tomography (observed LAC) and the theoretically calculated LAC (theoretical LAC) of standard materials (minerals and metals) has been obtained for an X-ray microtomographic system at BL20B2 of SPring-8, Japan. This system, called SP-μCT, uses highly monochromatized and well-collimated X-ray beams produced by a synchrotron radiation source. Three-dimensional images were obtained for samples 0.4–4 mm in size at X-ray energies of 15–35 keV with a voxel size of $5.83 \times 5.83 \times 5.83$ μm^3. A histogram of the observed LAC for each sample was well-fitted by a Gaussian curve except for heavy metals whose X-ray transmittance was insufficient. The contrast resolution of CT images is best (within 5% of the LAC value) at LACs of about 10–30 cm^{-1}. A garnet schist was imaged with SP-μCT to verify the observed–theoretical LAC relation for minerals contained in a rock sample. The result was consistent with the relation obtained for the standards. The CT and back-scattered electron images of the rock sample were compared. The present results put restrictions on discrimination of mineral phases and estimation of chemical compositions (e.g., Mg/Fe ratio) of certain minerals forming solid solutions based on CT values. The present quantitative relationship between observed and theoretical LACs enables us to obtain an absolute elemental concentration map by imaging just above and below the X-ray absorption edge energy of the element (subtraction method).