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First application of scintillator-based photon-counting computed tomography to rock samples: Preliminary results and prospects

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Abstract

Knowledge of the three-dimensional distribution of minerals in a rock sample is of fundamental importance to deciphering a sample's properties and history. Attenuation-contrast X-ray computed tomography (X-ray CT) is widely used in the geosciences to determine the three-dimensional distributions of minerals or pores, or both. Photon counting CT (PC-CT) uses a novel energy-resolved X-ray detector that allows X-rays with a continuous energy spectrum to be detected separately within arbitrary energy ranges. Here we report the first results of applying laboratory-build PC-CT combined with multi-pixel photon counter (MPPC) to common minerals such as quartz and calcite. In the low-energy range, PC-CT produced higher contrast images than single-energy X-ray CT. Minerals were successfully identified from the relationships between the mean CT values for each energy window and the mean difference between pairs of energy windows. These results suggest that PC-CT can produce high-contrast images of minerals and may be able to distinguish mineral phases with different attenuation curves, even when their CT values are similar. We obtained CT images of minerals in a natural sedimentary rock sample, composed mainly of quartz and carbonate. Although the spatial resolution of the detector in this study was insufficient for the sample, the main carbonate veins were clearly visible as high carbonate-content areas in the PC-CT images. Given some prior knowledge of mineral phases from other methods, it may be possible to use PC-CT imaging to obtain further information about their chemical compositions.

Keywords: Photon counting X-ray computed tomography, non-destructive testing tools for rocks