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Automated high accuracy, rapid beam hardening correction in X-Ray Computed Tomography of multi-mineral, heterogeneous core samples

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X-ray Computed Tomography scanning is an innovative procedure that allows the internal structure of samples to be computed in 3D. It has completely revolutionized the way several measurements can be achieved in geoscience, including characterization of petrophysical properties of porous media. In order to provide accurate results, it is, of course, necessary to have high quality scan images, free of artefacts. One of the most problematic artefacts is beam hardening, which, in cylindrical shapes, increases the attenuation values with increasing distance from the centre. Until now, no automatic solution has been proposed for cylindrically-shaped cores that is both computationally feasible and applicable to all geological media. A new technique is here introduced for correcting the beam hardening, using a linearization procedure of the beam hardening curve applied after the reconstruction process. We have developed an automated open source plug-in, running on ImageJ software, which does not require any a priori knowledge of the material, distance from the source or the scan conditions (current, energy), nor any segmentation of phases or calibration scan on phantom data. It is suitable for expert and non-expert use, alike. We have tested the technique on μCT scan images of a plastic rod, a sample of loose sand, several heterogeneous sandstone core samples (with near-cylindrical shapes), and finally, on an internal scan of a Berea sandstone core. This last sample was also scanned using a medical X-CT scanner with a fan-beam geometry, as opposed to a cone beam geometry, showing that our algorithm is equally effective in both cases. Our correction technique successfully removes the beam hardening artefact in all cases, as well as removing the cupping effect common to internal scans. For a Berea Sandstone, which varies in porosity from 19%-20%, porosity calculated using the corrected scan is 20.54%, which compares to a value of 14.24% using the software provided by the manufacturer.

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