1.9.21. POROSITY DETERMINATION IN FIRN ICE CORES USING QUANTITATIVE COMPUTED TOMOGRAPHY METHODS

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The constitution of polar ice cores, especially the air bubbles, porosity and their distribution are an important field of glaciology. An automated analysis of ice cores from various depths in glaciers allows conclusions about climatic changes during the past centuries. Cores with a length of 1 m and with a diameter of 10 cm of firn ice have to be processed in their full size in order to find out about the mean porosity of the ice core. The state of the art method for porosity measurements of ice cores is using a radio active source with mono-energetic gamma emission lines and calculating the irradiated path length directly from the attenuation. This method is sensitive to exact knowledge of geometric dimensions of the firn core. Broken pieces or cut-outs distort the calculated porosities immensely.

Computed Tomography (CT) is not a quantitative method per se, because of effects as beam hardening and scattered radiation. Both effects lead to an artefact known as cupping. It describes the effect of the attenuation coefficient being reconstructed too small, resulting in a cup shaped gray value profile in the reconstructed cross-section of an actual homogenous object. Provided these effects are accurately corrected, the mass density ρ of a mono-material can be calculated from the reconstructed CT-value (the attenuation coefficient) by calibration with a known test object of the same material with mass density ρ_0. In case of a porous material, the porosity p can be obtained by performing a CT scan with less resolution than the pore size, yielding an averaged value for the density. In this case the porosity can be calculated by $p = 1 - \rho/\rho_0$.

In a two stage approach both above-mentioned artefacts are corrected leading to a quantitative accurate CT images. In the first stage, the scattered is dealt with. As the geometry of the object is known, it is feasible to simulate the amount and distribution of scattered radiation with Monte-Carlo-Simulations. Figure 1a shows the simulated projection

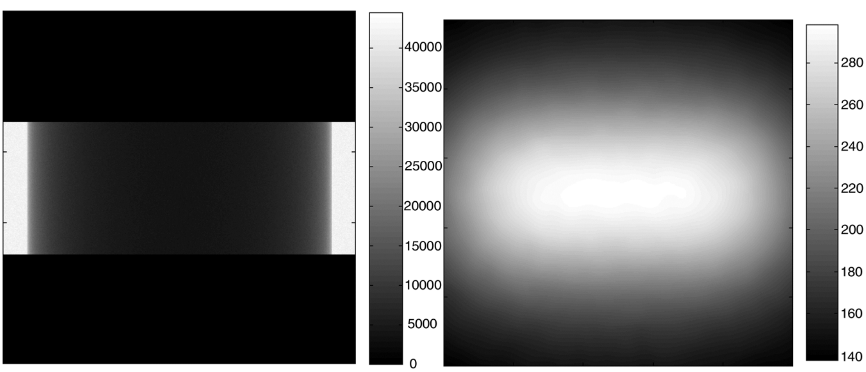

Fig. 1. (a) Simulated projection image of the phantom setup and (b) proportion of

scattered radiation

of PMMA cylinder (PMMA has similar X-ray attenuation to water). The dark regions on the top and bottom result from source side collimation of the X-ray beam, to keep scattered radiation as low as possible from the beginning. Figure 1b shows the scattered radiation from this setup. Provided that the setup of the real measurement is equivalent to the simulated one, the signal produced by the scattered radiation can now be subtracted from the measured projections.

In the second stage, the effect of beam hardening is corrected. This is achieved by using a look up table (LUT) which maps the grey value from the X-ray detector to an irradiated path length through the material. It can be generated employing the geometrically well known calibration phantom.

The developed methods will be presented. Porosity measurements of firn cores using quantitative CT images will be shown and discussed.