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Combining micro-CT data and XRF spectra for advanced element analysis

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Micro-computed tomography (μCT) is a very powerful tool for analysing geo-materials. However, this technique does not provide information about the elemental composition. Different compounds of the material can be reconstructed and visualised based on their attenuation coefficient, but cannot be identified. A combination of μCT data with X-ray fluorescence (XRF) can provide this additional information. In XRF, incident photons from the X-ray source are absorbed, ejecting an electron from an inner shell of an atom. The resulting vacancies are filled in by electrons from outer shells, emitting X-rays with an energy characteristic for the given atom. By measuring this fluorescent spectrum, the chemical elements present in the material can be determined. Based on the peak area of the XRF line, the concentration of the corresponding element can be estimated. The combination of this technique with μCT can be very valuable in the field of geo-sciences and other related research domains.

In this study, two different applications of the combination of XRF and μCT will be discussed. The first application obtains chemical information on the different compounds in the inner part of a granite. This information cannot be measured directly with XRF, but can be derived from the combined XRF spectra and μCT data. In the second application, the chemical elements present in volcanic rock are analysed, providing information about their origin.

For the first application, a Precambrian granite from China was scanned at the Centre for X-ray Tomography of the Ghent University (UGCT) at high resolution (voxel size less than 5 micrometer) and subsequently scanned with the Eagle III micro-XRF scanner from the Ghent University X-ray Microspectroscopy and Imaging Group (XMI). From the μCT-scan, a 3D volume was reconstructed, where the gray value of a volume element (voxel) is proportional to the mass attenuation coefficient of the concerned voxel. The μXRF imaging on the surface of the rock sample was performed with a spatial resolution of 100 μm in vertical and horizontal direction. Extraction of the elemental XRF line intensities for each pixel spectrum results in 2D elemental images of the sample surface. Through segmentation of the 3D volume, we were able to extend the information from this surface map to the whole volume. With this extra information, the granite can be characterized in a more correct way.

For the second application, a series of scoria and pumice, coming from the area west of the Lac Pavin (lake in Auvergne, France), were scanned with the UGCT μCT-scanner. The goal of this project is to distinguish different eruption facies, in particular the ‘red scoria’ layer, which is assumed to be the result of the most recent eruption in Western-Europe. Due to the irregular form of the samples, measuring a surface map of the elements was almost impossible. Therefore, only a global XRF-spectrum was taken with a Canberra X-PIPS detector at the UGCT facility. Although this result does not allow an identification of the different structures in the sample, knowledge of the abundance of chemical elements in the fragments can help to identify and characterize different eruptions.