Geophysical Research Abstracts, Vol. 7, 01713, 2005
SRef-ID: 1607-7962/gra/EGU05-A-01713

Neutron radiography of rocks and melts

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The large penetrating power of neutrons makes them ideal probes to investigate bulk samples. In addition to diffraction and spectroscopic experiments, neutrons can be used to directly observe the distribution of elements and processes in bulk samples.

Real time neutron radiographic observations of processes allow, for example, the observation of falling spheres in silicate melts, and of the dynamics in inhomogeneous systems composed of melts with different densities. Static images obtained for different sample orientations can be used to construct three-dimensional tomographic images. The whole neutron beam can be used to illuminate the sample,

so that samples with a diameter of up to 5 cm and a height of 10 cm can be used. The spatial resolution is about 0.3 mm for real time imaging, and about 0.1 mm for static images.

We will present three examples for neutron radiographic applications, namely (i) high accuracy falling sphere experiments in silicate melts, (ii) the visualisation of the flow of two immiscible melts and (iii) the use of neutrons to obtain information of the interior of bulk rocks.

(i) Our high accuracy falling sphere experiments, in which we varied the d/D-ratio (d = diameter of sphere, D = diameter of crucible) discontinuously by using 'stepped' crucibles, were the first attempt to experimentally verify the applicability of the so-called Faxen correction factor. This correction factor is often employed to correct for the finite sample size. Our experiments imply that the commonly used, theoretically derived, Faxen correction factor is about 10 percent too large.

(ii) The dynamics of two immiscible melts at high temperature were experimentally observed by neutron radiography and compared with finite-difference calculations. In the latter, the experimental parameters (viscosity and density differences, sample geometry) were used as input parameters in the calculations. The dynamics of the melts were reproduced by the simulation. Hence, the mathematical model used is sufficient and properties which have not been included in the model, such as surface tension, are thereby demonstrated to be of minor relevance for this specific experiment.

(iii) We have investigated the applicability of neutron tomography to the study of the structure of bulk rock samples. We show that high resolution measurements can be used to investigate the orientation of crystals in coarse grained rocks, allow the study of pore systems and can be used for a semi-quantitative phase analysis.