Three Dimensional Structure of multiple vessels in the Organ Using Multiple Contrast Materials

*Chizuko Tsuji (5597), Etsuro Tanaka (5137), Yoshiro Shinozaki (5173), Yoshinori Sugiy (5145), Koji Kimura (5874), Toshinori Fujikura (5266), Eriko Kuwabara (6400), Naoto Fukuyama (5733), Yutaka Shoyama (5772), §Kentarou Uesugi (1544), §Keiji Umetani (1460), SNaoki Nishiura (6477), SHidezo Mori (1795)

Departments of Physiology and Surgery, Tokai University School of Medicine, Isehara, Japan, §The Japan Synchrotron Radiation Research Institute (JASRI) and §Department of Cardiac Physiology, National Cardiovascular Center Research Institute, Suita, Japan.

The lung has two vascular systems, pulmonary and bronchial circulations. The purpose of this study is to visualize each vessel separately and three dimensionally. In the anesthetized rabbit and rat, pulmonary and bronchial arteries were filled up 1-labeled and Ba-labeled microspheres with a diameter of 15 μm, as the contrast materials for x-ray imaging. The respiratory tract was also filled up with Ce-labeled microspheres and agarose. The lung was dissected out and fixed with formalin-saline, and the tissue samples 3 mm in diameter and 10~20mm in length were excised. The samples were exposed to monochromatic synchrotron radiation with just upper and lower energy levels of K-edge in each element (in I and Ba, upper levels are 33.2 and 37.45 keV, and lower levels are 33.15 and 37.42 keV respectively). To construct the CT-images, the samples were taken every 0.5 degree angle, turning it for 180°.

Shape and connectivity of melt and void on the grain boundary control the bulk properties of rocks such as fluid permeability and electric conductivity. In this study, we obtained the 3-dimensional X-ray CT images of rocks using the X-ray tomographic microscope (XTM) at BL20B2, and tried to clarify the μm-scale structure of melt and void in each sample in order to improve the models of fluid flow process in the Earth’s interior.

For various photon energies, we measured the following samples by the XTM. Samples-P: two pumicites of 1986 Izu-Oshima eruption. Samples-V: natural sandstone and granite with known porosities and permeabilities. Samples-M: two synthetic partial melting granite analogues including the melt as quenched glass. From the measured X-ray projections of them, we reconstructed the 3-dimensional X-ray CT (XTM) images.

Using the software reported in 2000B0462, we analyzed the shape and size distributions of bubbles in the samples-P. There is no preferred orientation of bubbles in both pumicites. Dominant sizes of bubbles in the pumicites are different in each other. However, the characteristic of the size distributions is not consistent with the description of a previous study.

As reported in 2000A0125 and 2000B0462, we can identify a comparatively wide void in a rock based only on the estimated value of X-ray linear absorption coefficient (LAC) in an XTM image. However, to visualize the narrow void almost the same width as the spatial resolution of the XTM, it is necessary to fill a contrast medium to there. In this study, we measured the samples-V which filled the potassium-iodide solution as the contrast medium. Since LAC of the solution was not higher than that of biotite (iron-rich mineral in sandstone and granite), we used the AE-sandwiched dual energy X-ray CT technique: two XTM images for each sample were obtained using the photon energy just below and above the X-ray absorption edge (AE) of iodine. The 3-dimensional distribution of narrow voids in each sample could be visualized in the differential CT image.

As reported in 2000A0321, contrast of the LACs among solid and melt phases in the partial melting rock is very small, and it is necessary to add the incompatable element (the element which concentrates to the melt) to the sample as the contrast medium. Similar to the experiment of 2000B0462, we synthesized the samples-M with a few % of cesium (Cs) as the contrast medium. We also used the AE-sandwiched dual energy X-ray CT technique: two XTM images for each sample were obtained using the photon energies just below and above the AE of Cs. Slices of the differential CT images correspond well with the distribution maps of Cs obtained by the electron-probe micro-analyzer. However, the density of Cs estimated by the XTM images changed gradually at each slice. This might be not the true distribution of Cs but the artifact. Preliminary measurement of the Cs-compound solution showed that the photon flux monochromatized by the XTM had weak spatial fluctuation of energy. To apply the XTM image to the 3-dimensional element mapping, we should perform the precise calibration of photon energy (both spatial and spectral distributions of the photon energy) for the XTM.

---

Figure: Images of the pulmonary artery (A) and the bronchial artery (B) in the rat lung.