Microstructure of Wood's Metal-Filled Fontainebleau Sandstone

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Introduction

There are several reasons for using the Wood's metal intrusion technique in preparing samples for investigations of porous media using synchrotron computed microtomography (CMT) in porous media. First, its x-ray absorption coefficient is much higher than the coefficient for sandstone or other rocks. Hence, filled pore spaces may be identified at spatial resolutions substantially better than would be expected from the nominal instrumental resolution. Second, the ability to freeze the flow of the Wood's metal in the media makes possible the detailed study of the flow of a liquid through a porous medium, which would be difficult or impossible with a fluid that is liquid at room temperature. Third, study of microcracks as a function of pressure is facilitated. Fourth, pore-scale CMT results may be helpful in the understanding and interpretation of mercury intrusion porosimetry.[1] An example of the use of Wood's metal porosimetry for study of cement pore structure is given by Willis and others.[2]

Methods and Materials

We used synchrotron CMT to investigate the pore structure of Fontainebleau sandstone filled with Wood's metal. The CMT experiments were carried out at the Brookhaven National Synchrotron Light Source (NSLS) and at the Argonne Advanced Photon Source (APS). A third-generation apparatus was used in both cases at voxel sizes of about .020 mm. A filtered white beam with a mean energy of about 55 keV was used at the NSLS. The work at the APS was done with a monoenergetic beam at several energies between about 68 and 80 keV. The same sample of Fontainebleau sandstone with a nominal porosity of 5% (prepared by Professor Michel Darot, Strasbourg, France) was studied in both experiments.

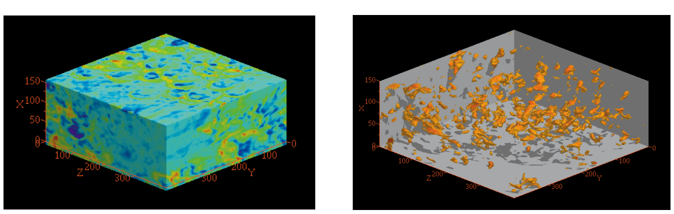

FIG. 1. NSLS tomogram showing sandstone grains and the distribution of Wood's metal. The sandstone is rendered transparent in the view at the right.

Results

The 3-dimensional distribution of Wood's metal in the sandstone that was measured at the NSLS is shown in Fig. 1. The pathways of the Wood's metal between filled pores was not revealed in this display. The percolation front between the Wood's metal filled space and native sandstone measured at the APS is shown in Fig. 2.

Discussion

The observed distribution of x-ray attenuation coefficients is dependent on the grain size distribution and the spatial resolution of the apparatus. This was seen in the histograms found for measurements at the NSLS (20 µm) and APS (100 µm). A peak corresponding to filled voxels is seen for the higher resolution data. The measurements did not show connectivity between the pores filled with Wood's metal, which is attributed to a spatial resolution large relative to the pore structures. They do show that Wood's metal impregnation can improve the volume resolution by a factor of 10 or more. The data presented here should be useful in theoretical modeling the flow of Wood's metal in a sandstone.

Acknowledgments

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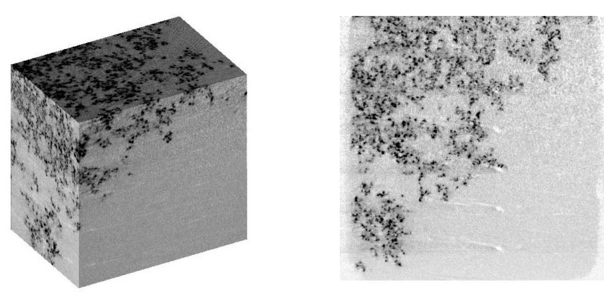

FIG. 2. APS tomogram showing the Wood's metal percolation front. The right-hand picture shows a vertical section through the block shown on the left. The sandstone grains are not shown in this display.