

# Visualizing aerosol transport through cracks in mortar matrices using x-ray microtomography

A. Boccheciampe<sup>1,2</sup>, D. Borschnek<sup>2</sup>, P. Chaurand<sup>2</sup>, I. Pointeau<sup>1</sup>, V. Vidal<sup>2</sup>, J. Rose<sup>2</sup>

<sup>1</sup>DFDE/SECC/LECD CEA CADARACHE, 13115 Saint-Paul-Lez-Durance, France

<sup>2</sup>Aix Marseille Univ, CNRS, IRD, INRAE, Coll France, CEREGE, 13545 Aix-en-Provence, France

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Corresponding author email: alexis.boccheciampe@cea.fr

In the context of nuclear activities, waste packages need specific management. For example, among radioactive waste, some are immobilized in metal drums embedded in mortar matrix.

Under normal conditions, the mortar barrier allows the release of radioactive gas ( $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{222}\text{Rn}$ ...), corrosion and radiolysis gas ( $\text{H}_2$ ,  $\text{CO}_2$ ,  $\text{CO}$ ,  $\text{CH}_4$ ...) but acts as a very efficient particles filter thanks to its mesoscopic porous network (porous diameter access of few nanometers). In case of serious adverse event like fire, fall... cracks can be formed into the mortar barrier, and preferential pathways can lead to radioactive aerosols leakage. Within the framework of the specific safety / security subject, it is important to quantify the amount of aerosols that can be released as a function of gas vector flow, crack geometry, particle size...

The objective of this study is to characterise aerosol transport and deposition directly in the solid matrix because of the low gas flows involved. To this aim, an innovative methodology was set up.

First, mortar cylinders ( $H=50\text{mm}$  and  $\varnothing=8\text{mm}$ ) are prepared, with internal controlled crack geometry. The crack geometry was obtained thanks to a 3D printed plastic mould (computer design) placed in the mortar sample. After curing time, the plastic mould was dissolved for leave only its footprint similar to a real crack. This method allows to create several cracked samples with the chosen geometric parameters. Each sample is made of one piece and can be employed many times after each analysis. This methodology opens the route to test reproducibility and variability of aerosol transport.

Secondly,  $\text{CeO}_2$  particles (mean diameter of  $40\ \mu\text{m}$ ), used as oxide of actinide or fission product analog, were injected in cracked mortar cylinder with a specific experimental setup to simulate aerosols migration. Then,

the particles deposite along the crack was observed in-situ using X-ray micro computed tomography (micro-CT).

Based on X-ray attenuation contrast between air, mortar matrix and  $\text{CeO}_2$  particles, the crack volume and the injected particles can be isolated and quantified from micro-CT image analyses (segmentation/thresholding procedure). Figure 1 shows an example of the 3D images obtained by micro-CT. Voxels associated to the mortar phases are coloured in blue. The image also reveals  $\text{CeO}_2$  particles (red voxels) distribution within the crack.  $\text{CeO}_2$  particles were injected with a high airflow rate (compare to radioactive waste package gas flow production) to ensure the particle penetration in the crack.

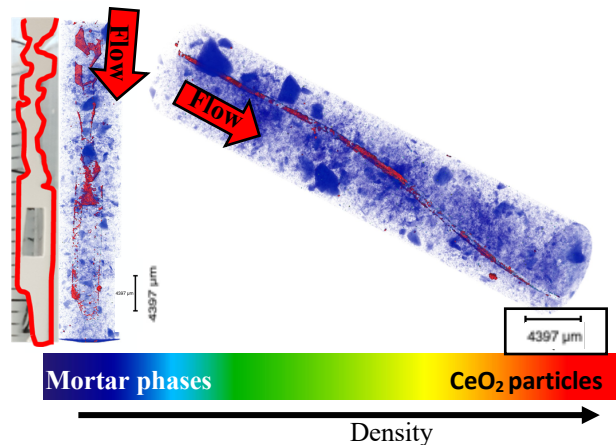


Figure 1: 3D images obtained by micro-CT (isotropic voxel size of  $10.4\ \mu\text{m}$ ) of a cracked mortar (in blue) in which  $\text{CeO}_2$  particles have migrated.  $\text{CeO}_2$  particles were isolated by thresholding and are colored in red.

These preliminary qualitative experiments show that this methodology is well adapted to study the transport of particles in mortar cracks. Then, a series of experiments will be carried out on new samples, using a screening approach, in order to investigate parameters controlling particles transport: particle size, flow, crack geometry...