Multiscale mapping of 3D Nanotomograms

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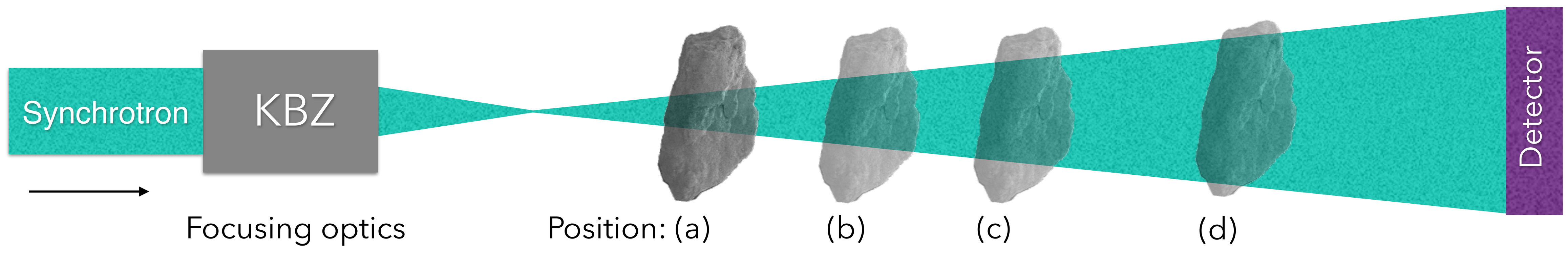
Introduction

Synchrotron based high resolution tomography can reveal fine structures in porous media but at high resolution, the field of view is restricted. On the other hand, lower resolution tomograms give a wider field of view but compromise the contrast of micro and nanostructures in the sample. To overcome this, we collected data at a range of resolution by linearly translating the sample along the conical beamline. Three dimensional (3D) tomograms obtained at each resolution were aligned and registered with subpixel accuracy 3D normalised cross correlation (also Fourier-Mellin method) to ensure that the same exact region was characterised. This allows us to develop a method for interpolating between physical observables over a range of length scales. The trend derived also suggests, what resolution is optimal for predicting a particular type of physical phenomena.

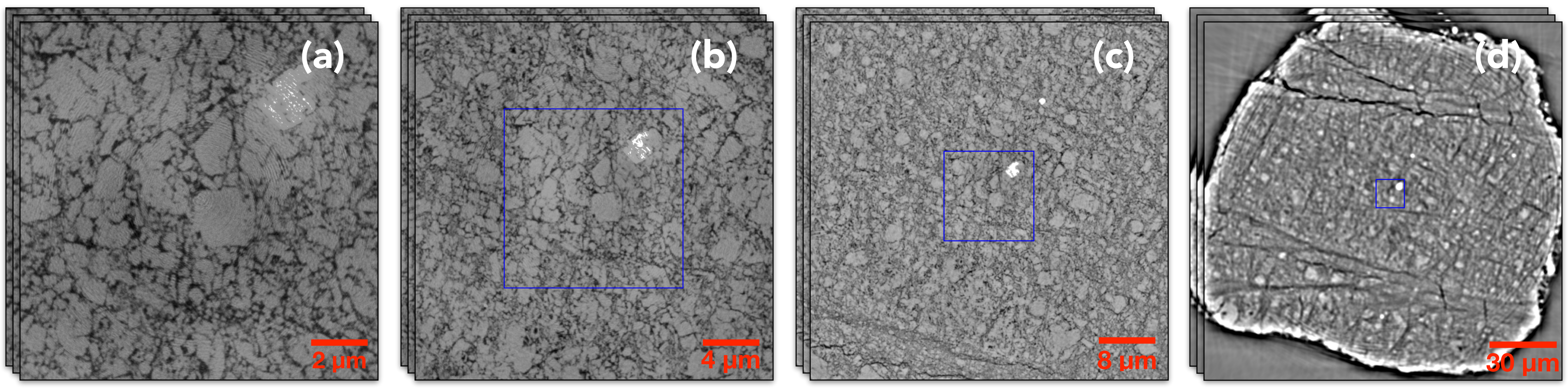
"Does resolution of tomograms affect the retrieved parameters?"

Experimental setup



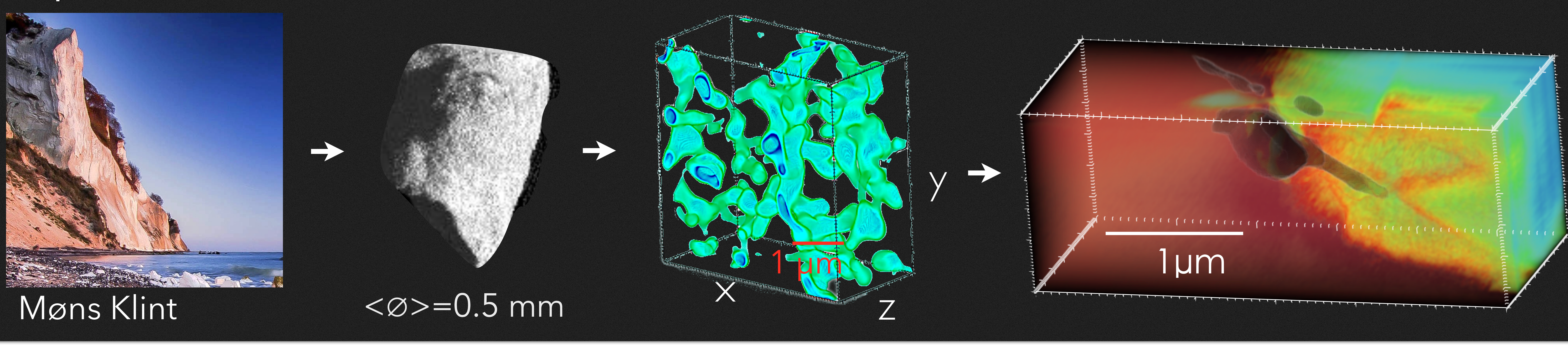
Multiscale measurement at ID-22 tomography beamline at ESRF, France. Linear translation along the beamline gives a series of images with magnification decreasingly as a function of distance from the detector.

Mapped 3D nanotomograms



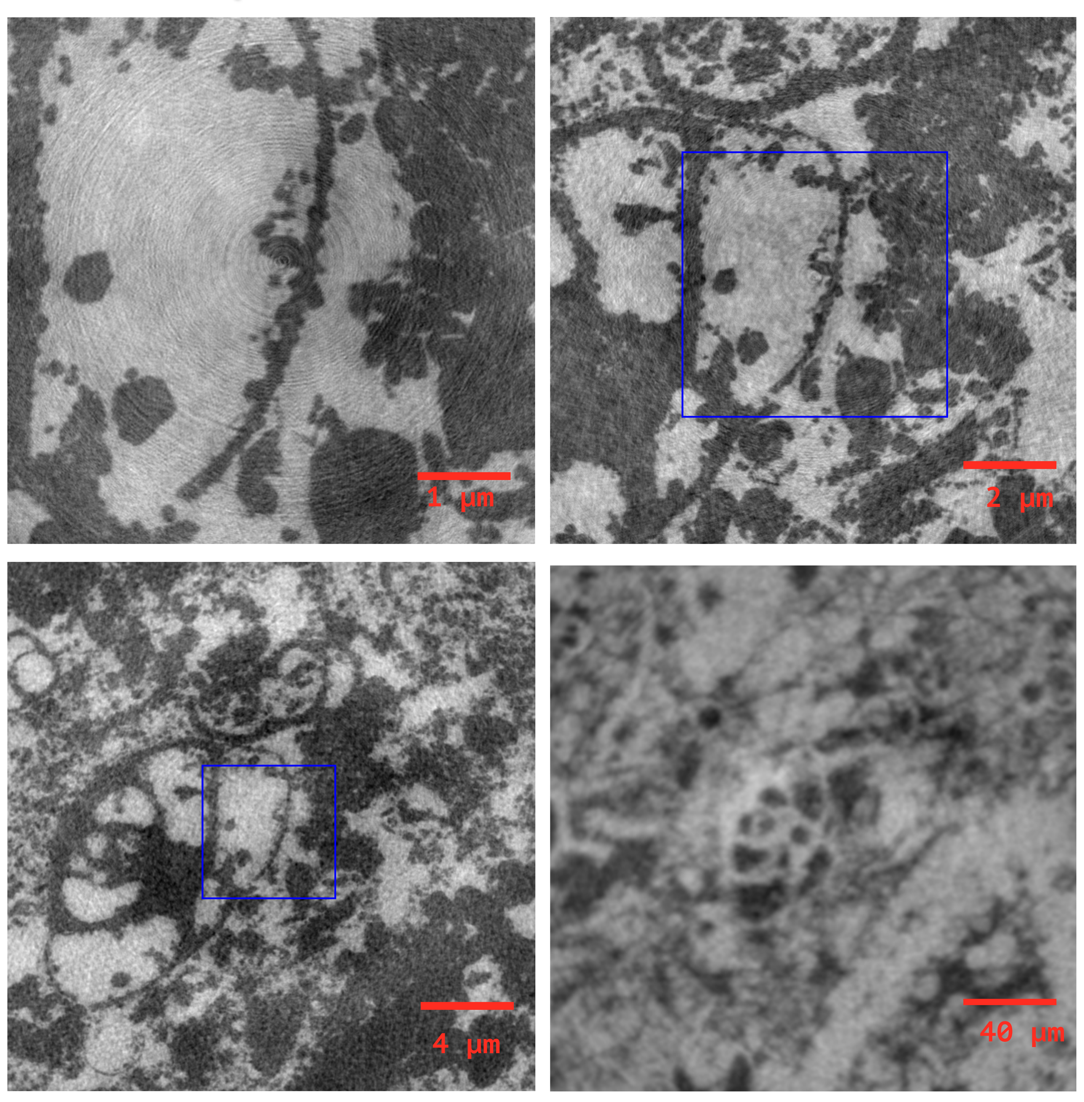
3D sub-volumes shown in the blue bounding box is registered at different resolutions tomograms. Tomogram (c) and (d) gives higher field of view but lower resolution unlike (a) and (b).

Purpose

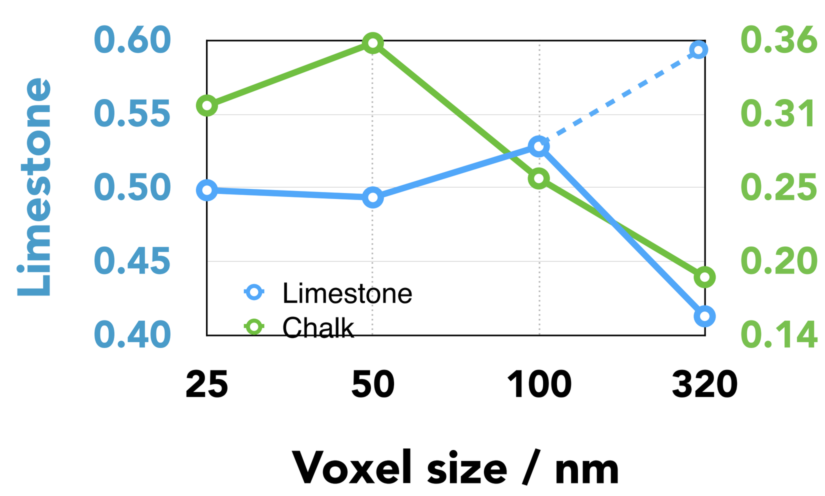


Compare the micro scale and macro scale physical properties retrieved from structural information!

High porosity limestone

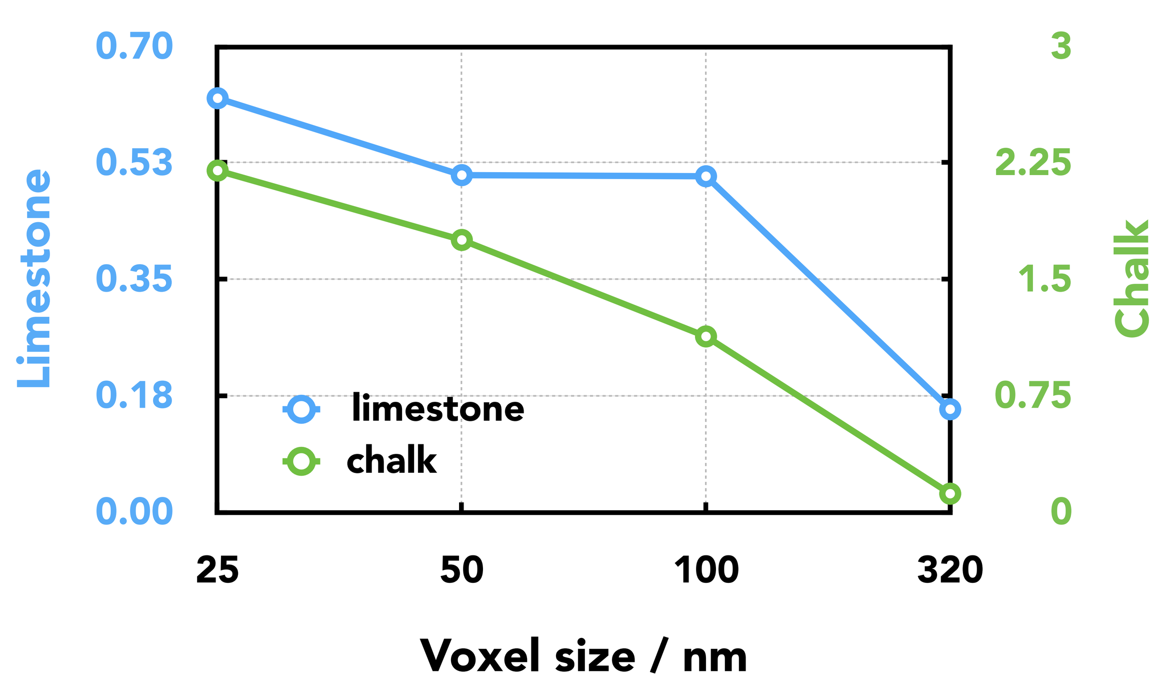


Porosity

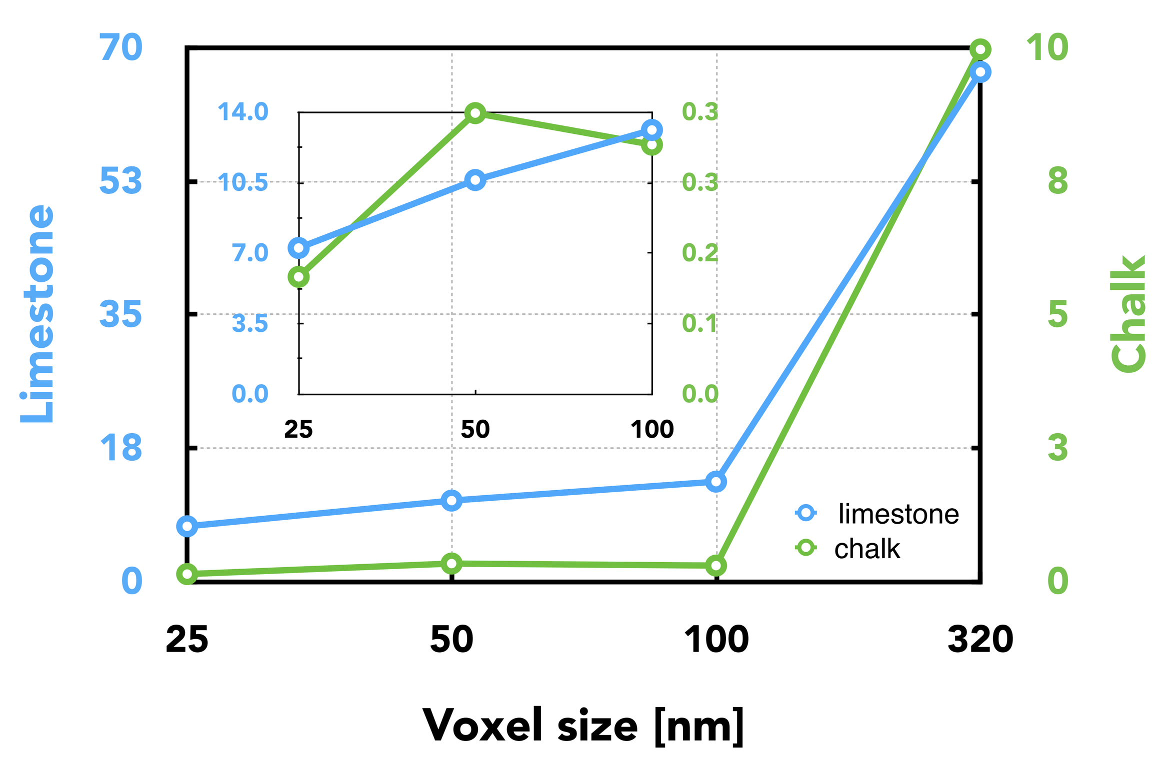


Porosity is either over or underestimated!

Specific surface area / [m^2/g]



Permeability [mD]



Conclusions:

- Cross-correlation in 3D Fourier space retrieves the translation in 3D space between data sets.
- Phase correlation by Fourier-Mellin method gives the translation in 2D and estimates rotation.
- The structural properties cannot be deemed accurate given the resolution is not optimum.
- High resolution and wide field of view datasets obtained at different settings or instruments can be virtually combined to a hybrid dataset.

References:

[1] *Yu Ren et al. (2013), Nature Communications, 4-2015*

[2] *Z. Liang, et al. (2000), Chemical Engineering Science, 55-22, p 5247-5262*

[3] *D. Müter et al. (2014), Appl. Phys. Lett. 105, 043108*

Acknowledgment

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