Characterization by X-ray µCT of the air-filled porosity of an agricultural soil at different matric potentials

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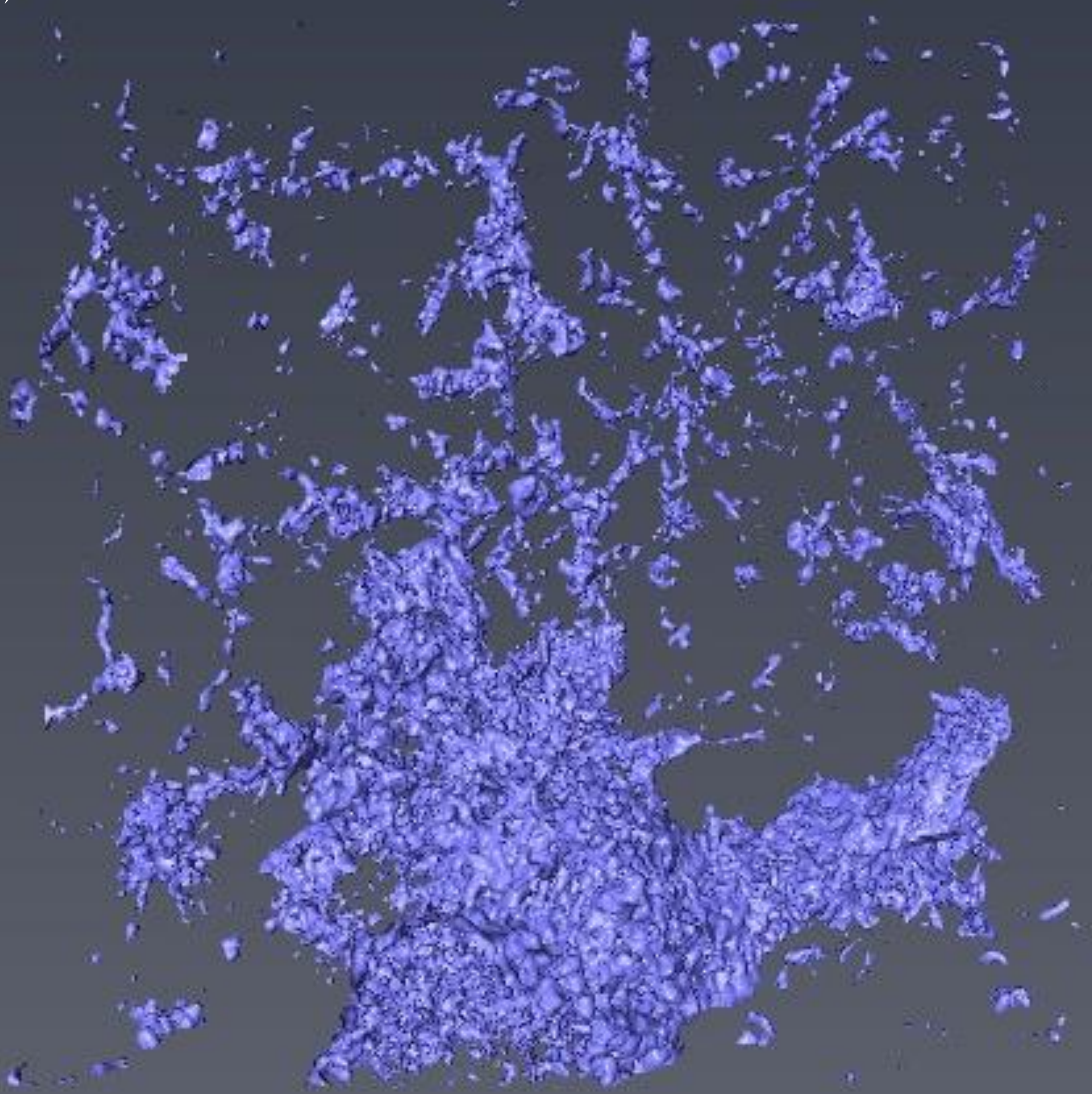
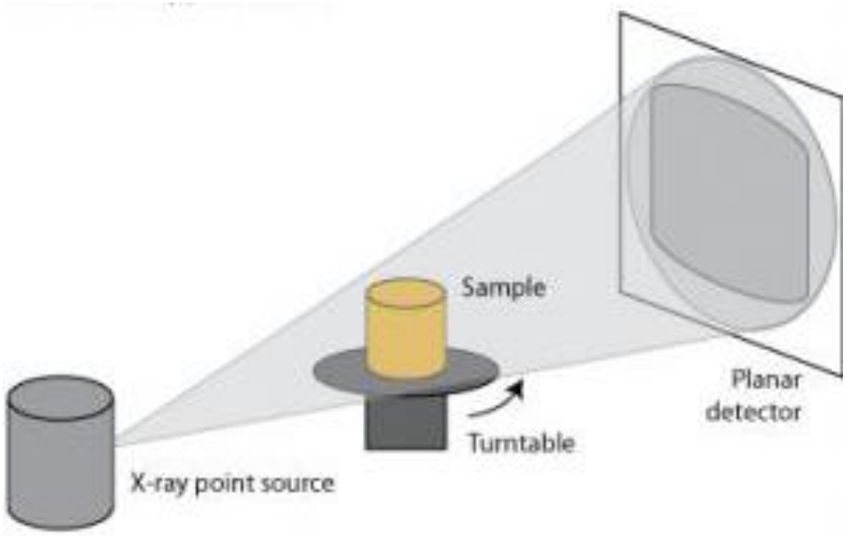
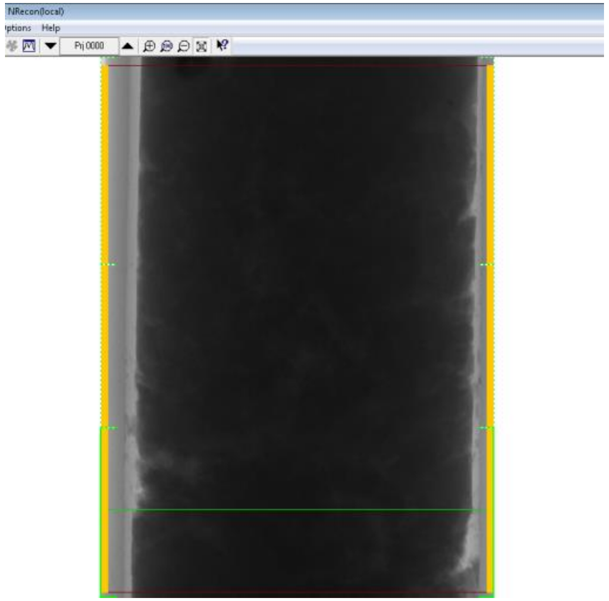
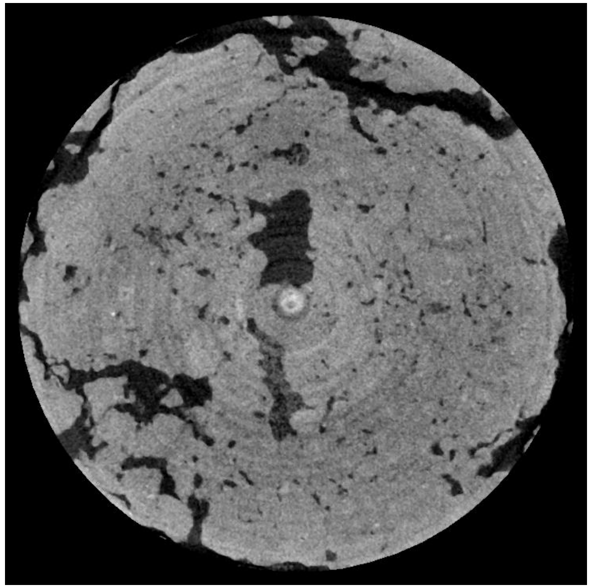
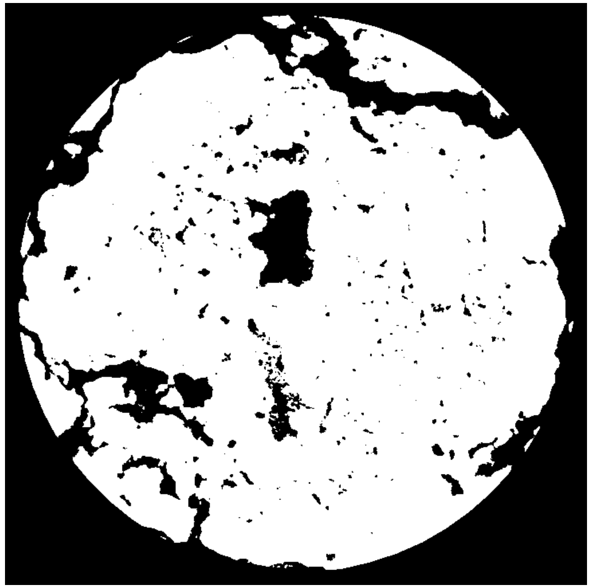
Work undertaken at Gembloux Agro-Bio Tech, University of Liège, Belgium, with a funding from FNRS

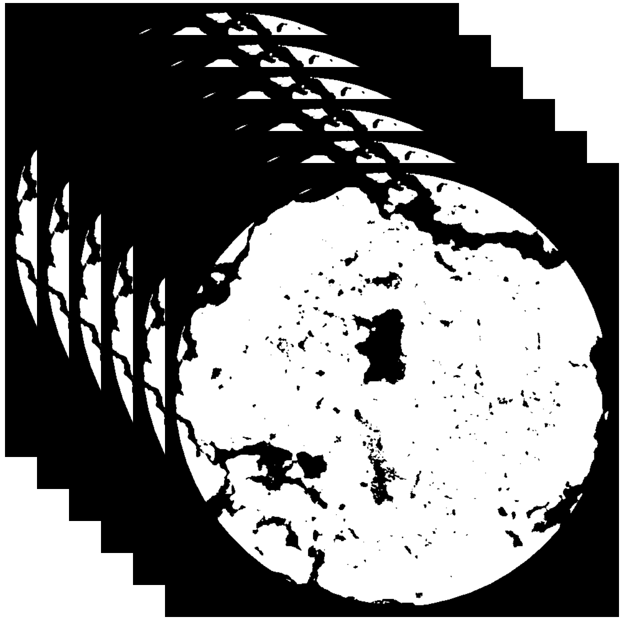



Sample
Planar detector
Turntable
X-ray point source

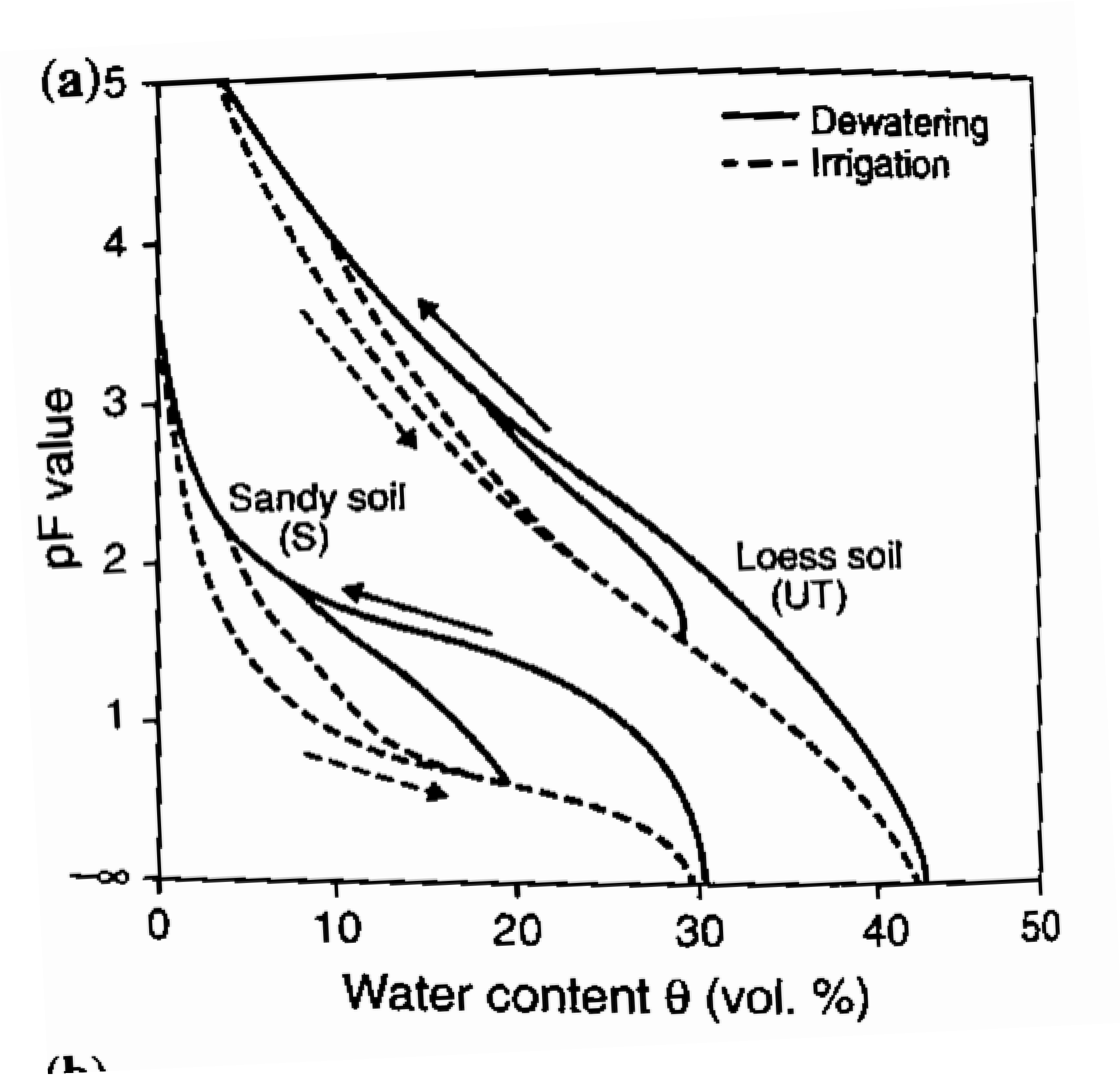


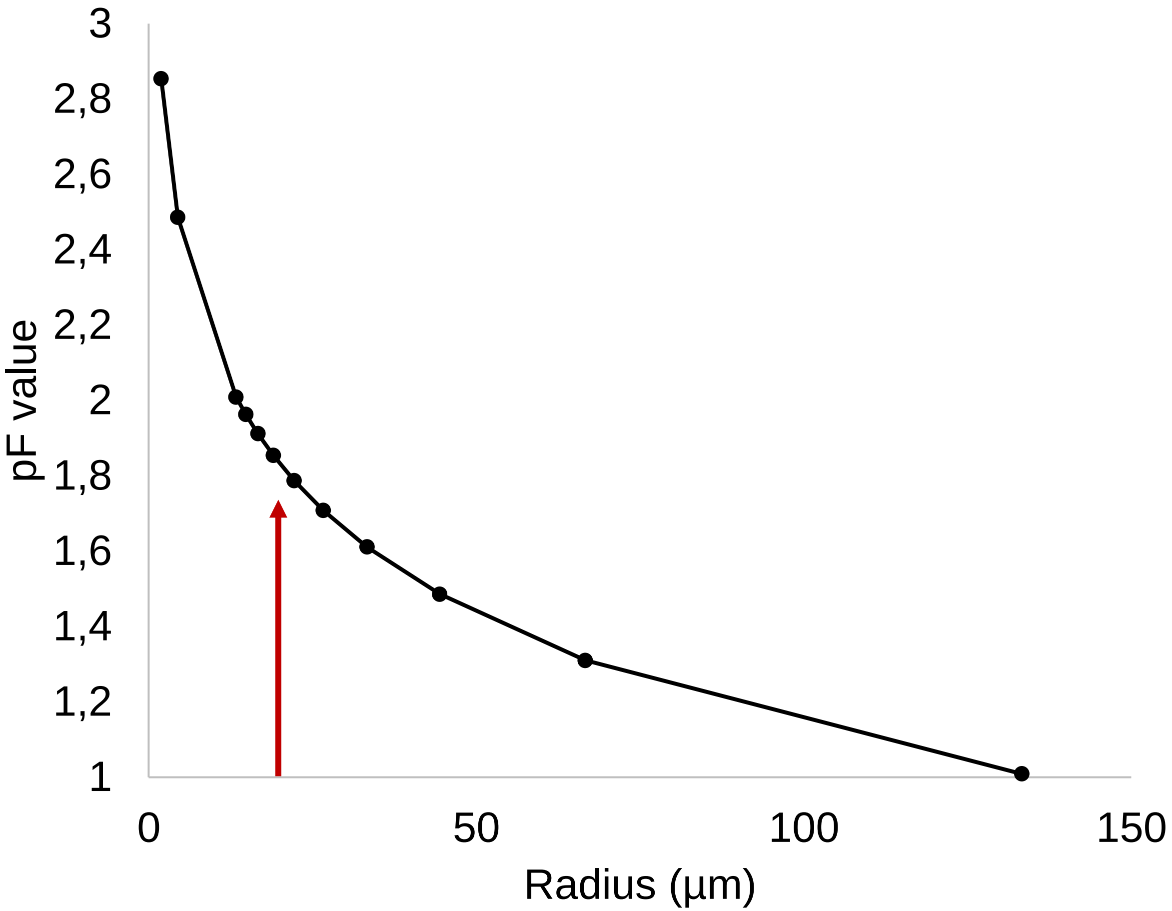






Air-filled pore space





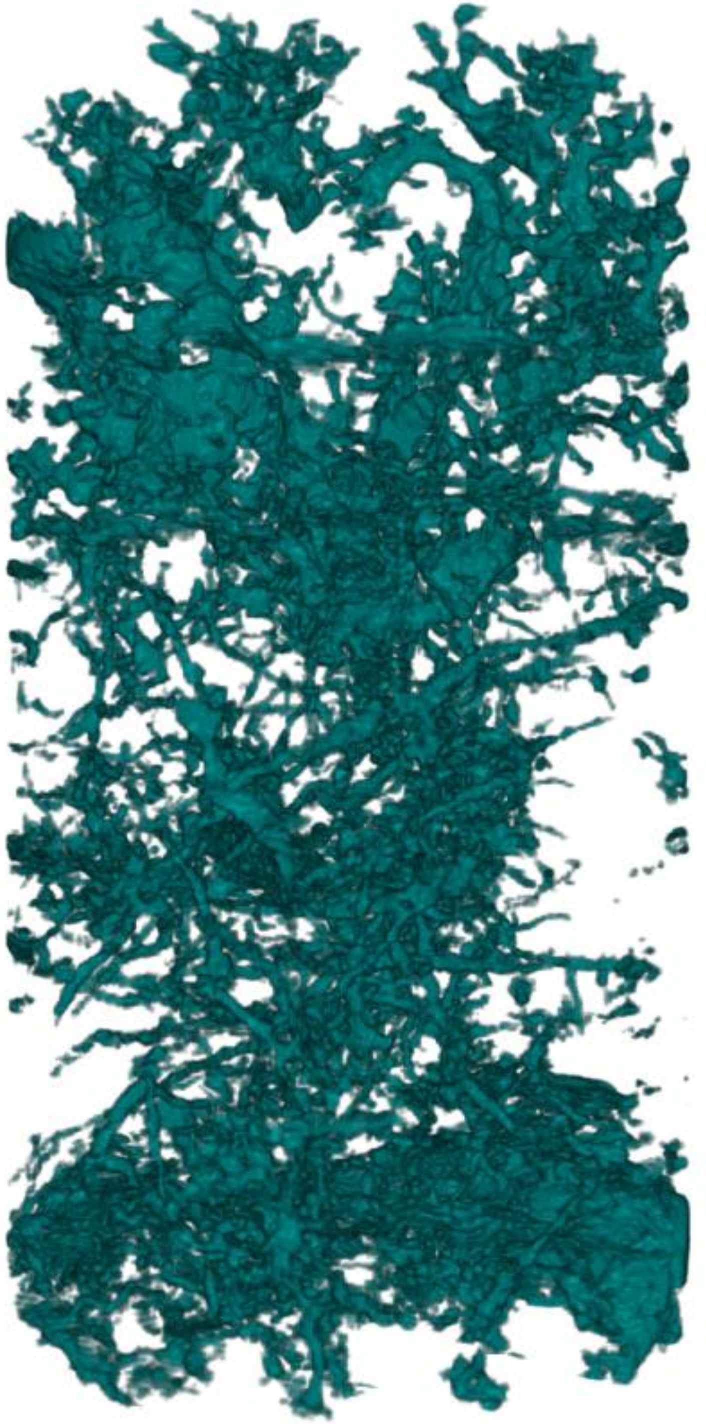
Source: Blume et al., 2015

Objective

Contribute to a better understanding of the soil hydrodynamics

Practically:

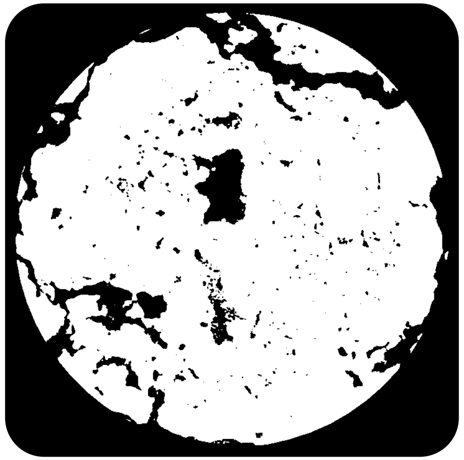
Quantitative assessment how the morphology of the air-filled pore space of a soil evolves as it is progressively dried

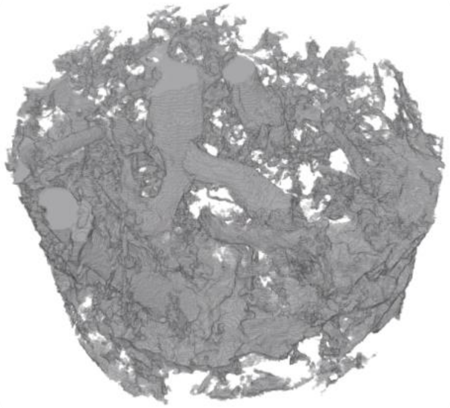


Materials & methods

n: 20 samples
Size: 3 x 5 cm
Soil: cutanic luvisol
Use: agricultural
[Mngt: till & no till**]**

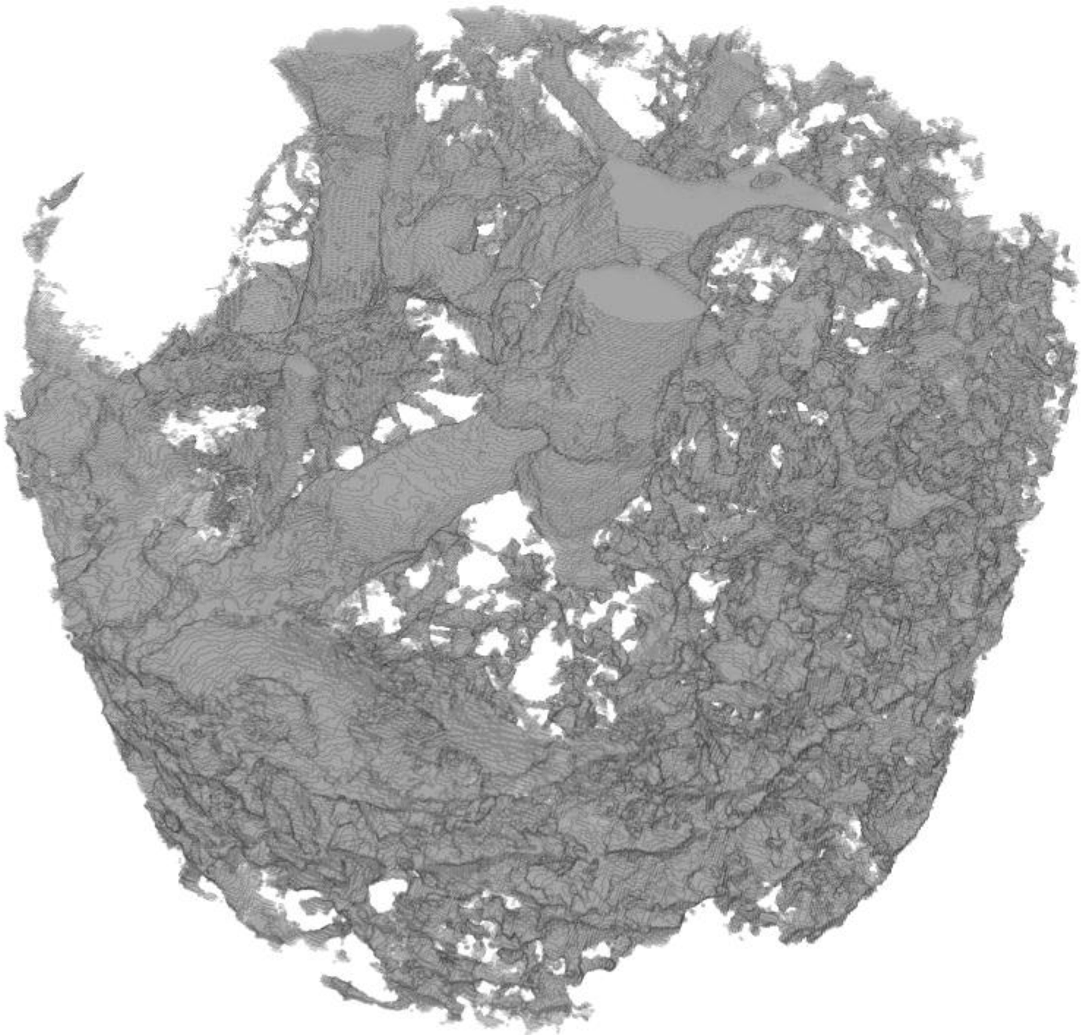
-4 kPa ● -7 kPa ● -10 kPa ● -30 kPa ● -70 kPa





X-ray micro-computed tomography (X-ray µCT)

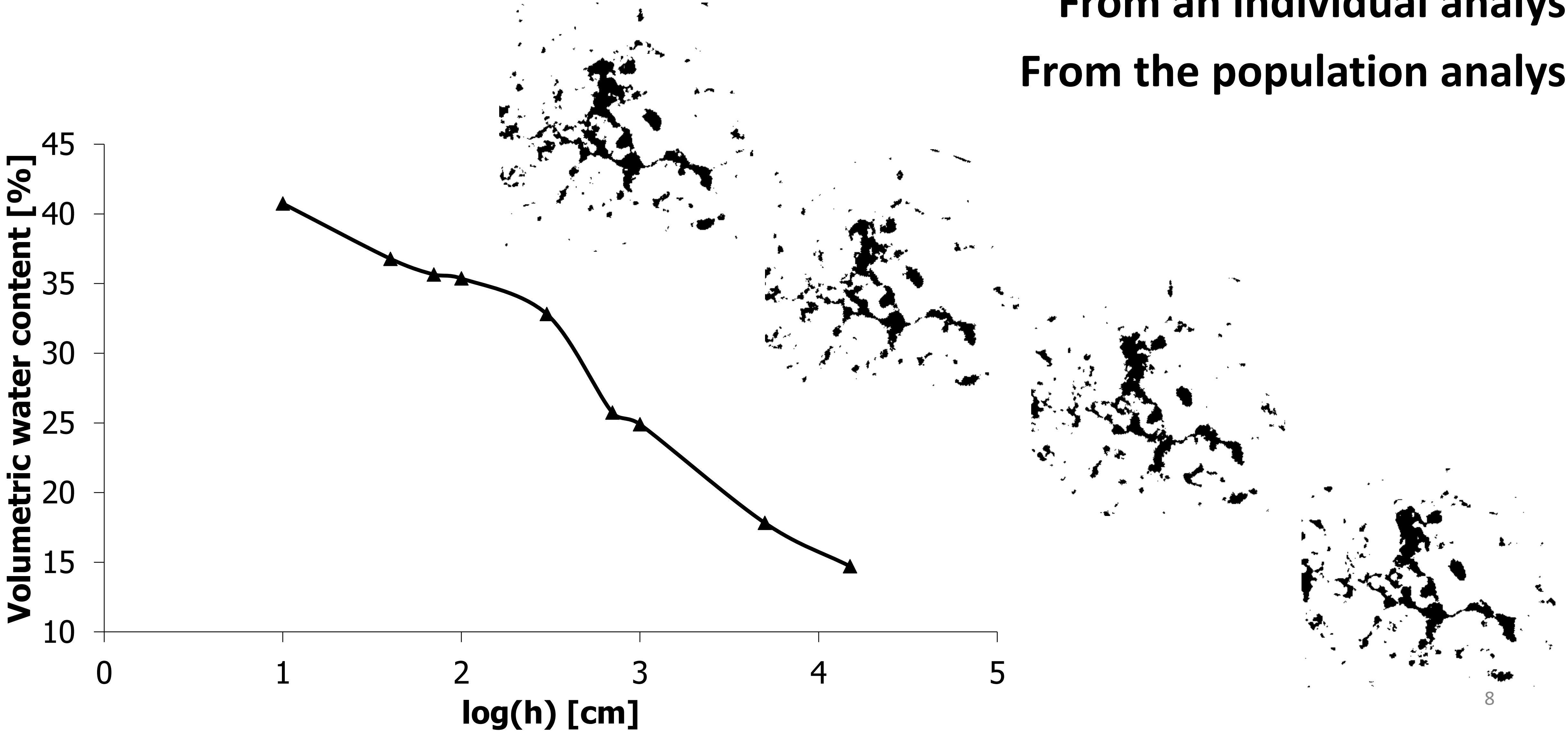
- Acquisition at 21,5 µm
- Resampling 43 µm
- 3D median filter (radius of 2 pixels)
- Global segmentation based on Otsu's & a porosity-based method
- Skeletonization
- Computation of morphological parameters
  - ✓ Geometric tortuosity
  - ✓ Fractal dimension
  - ✓ Connectivity
    - ➢ Euler number
    - ➢ Average Coordination number
    - ➢ Average surface connectivity
    - ➢ Global connectivity



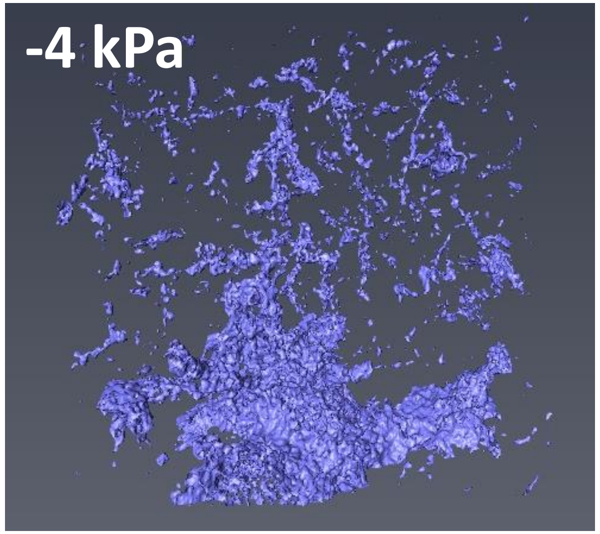
Results

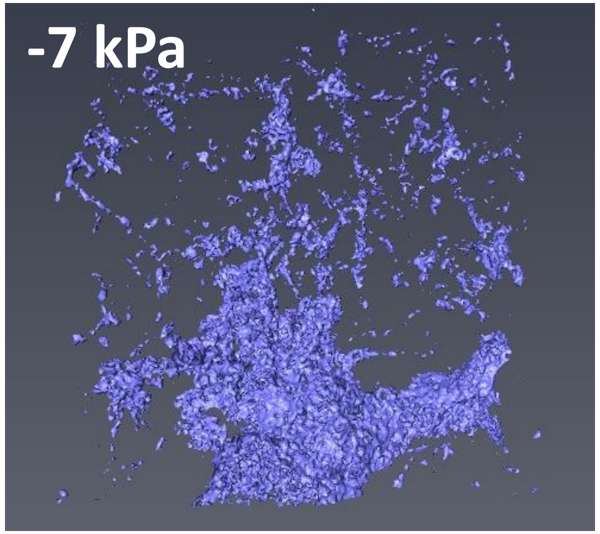
From an individual analysis

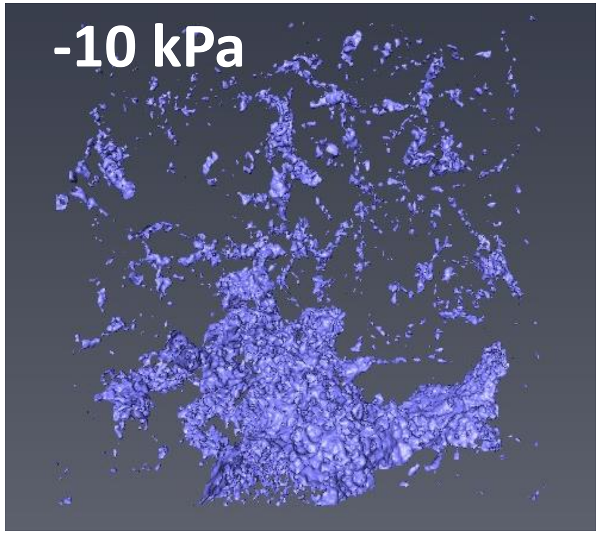
From the population analysis

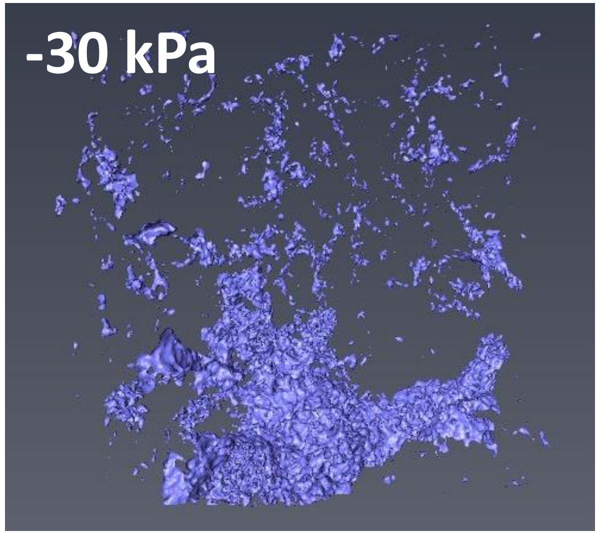


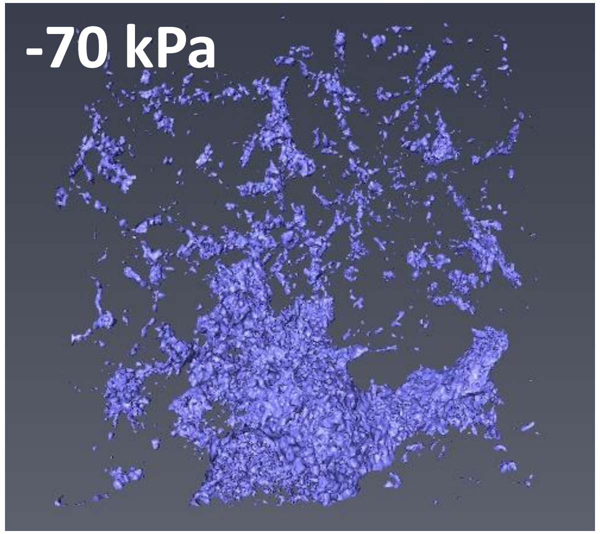
Results: from an individual perspective



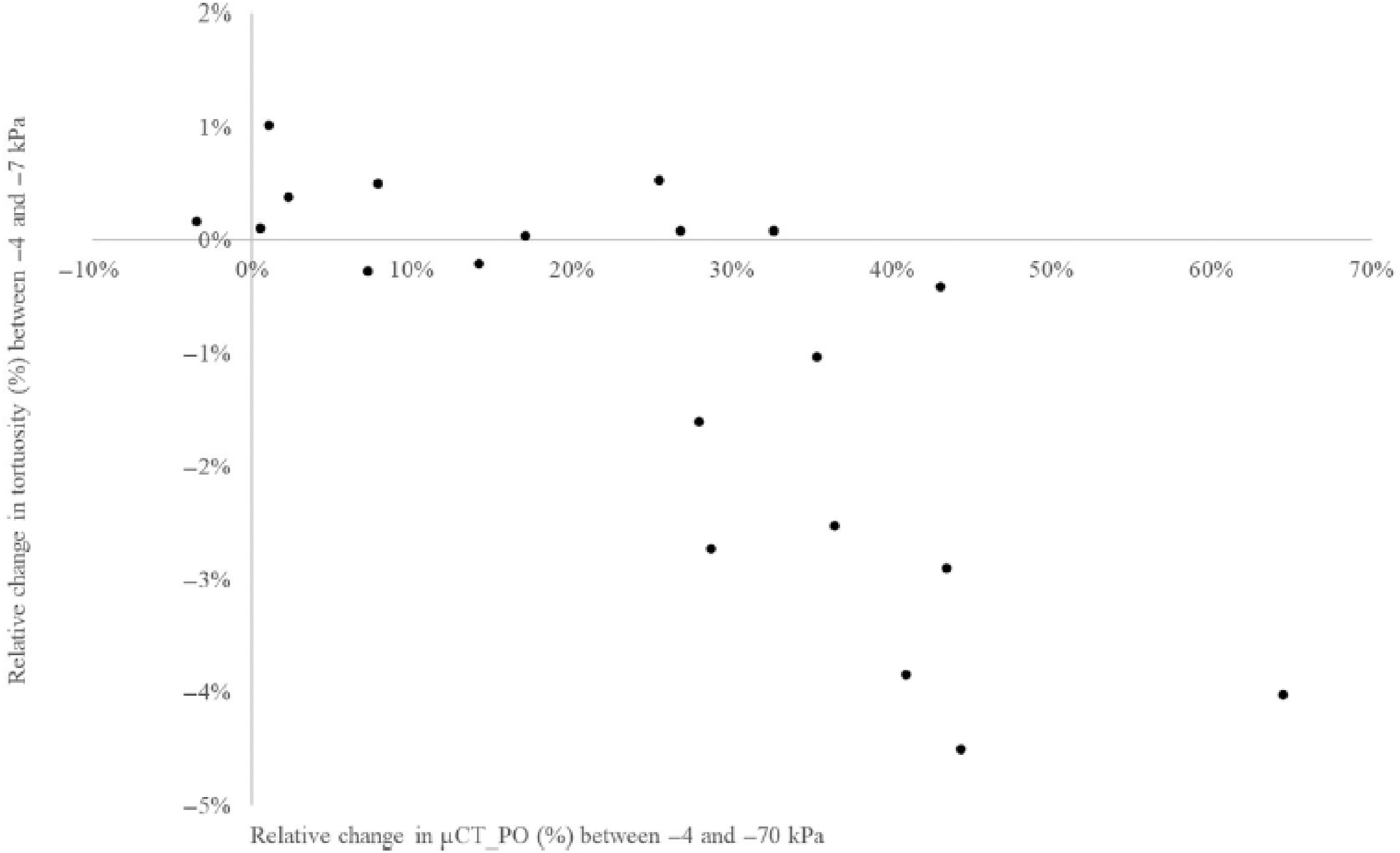








Results: from an individual perspective



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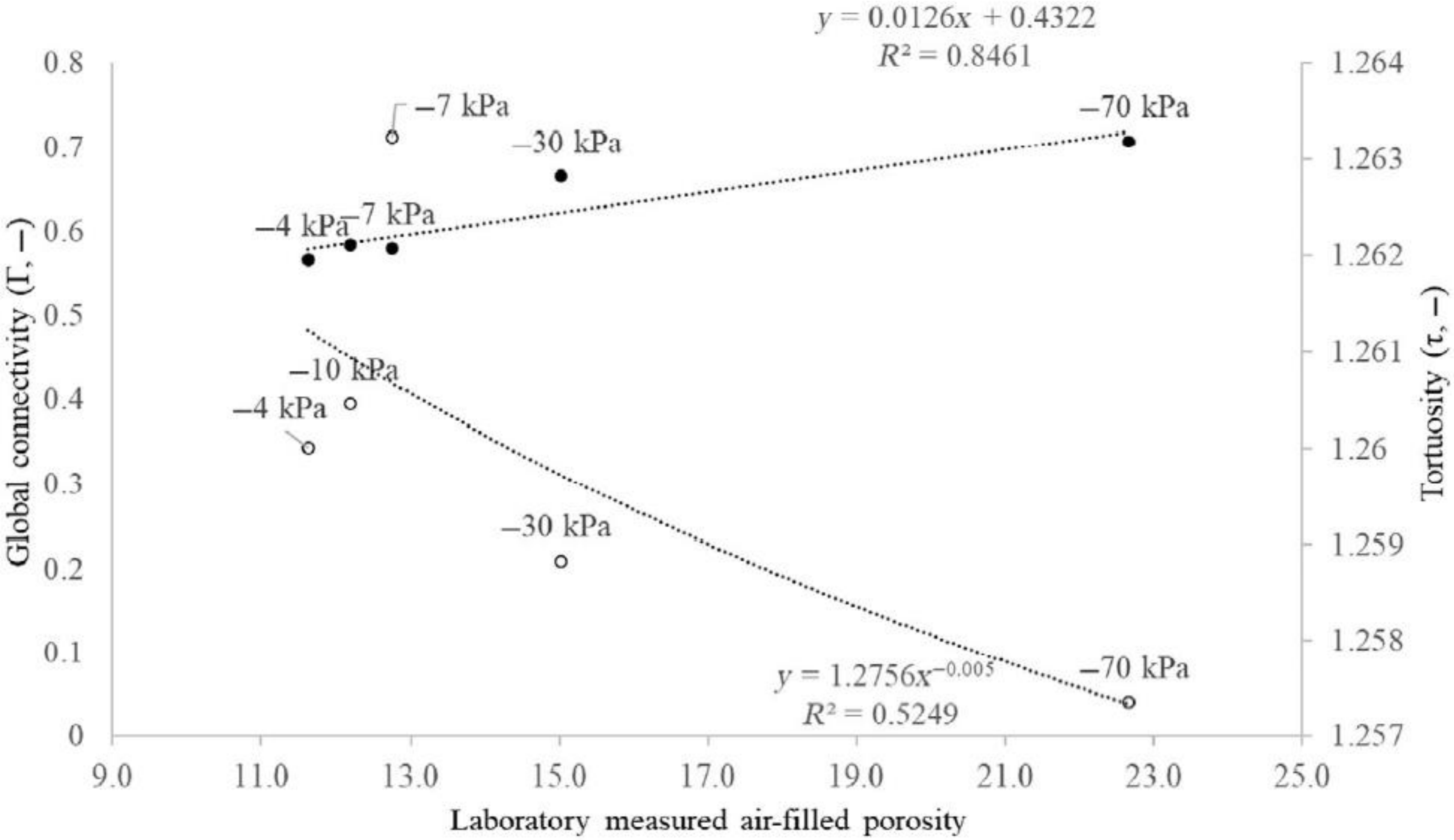
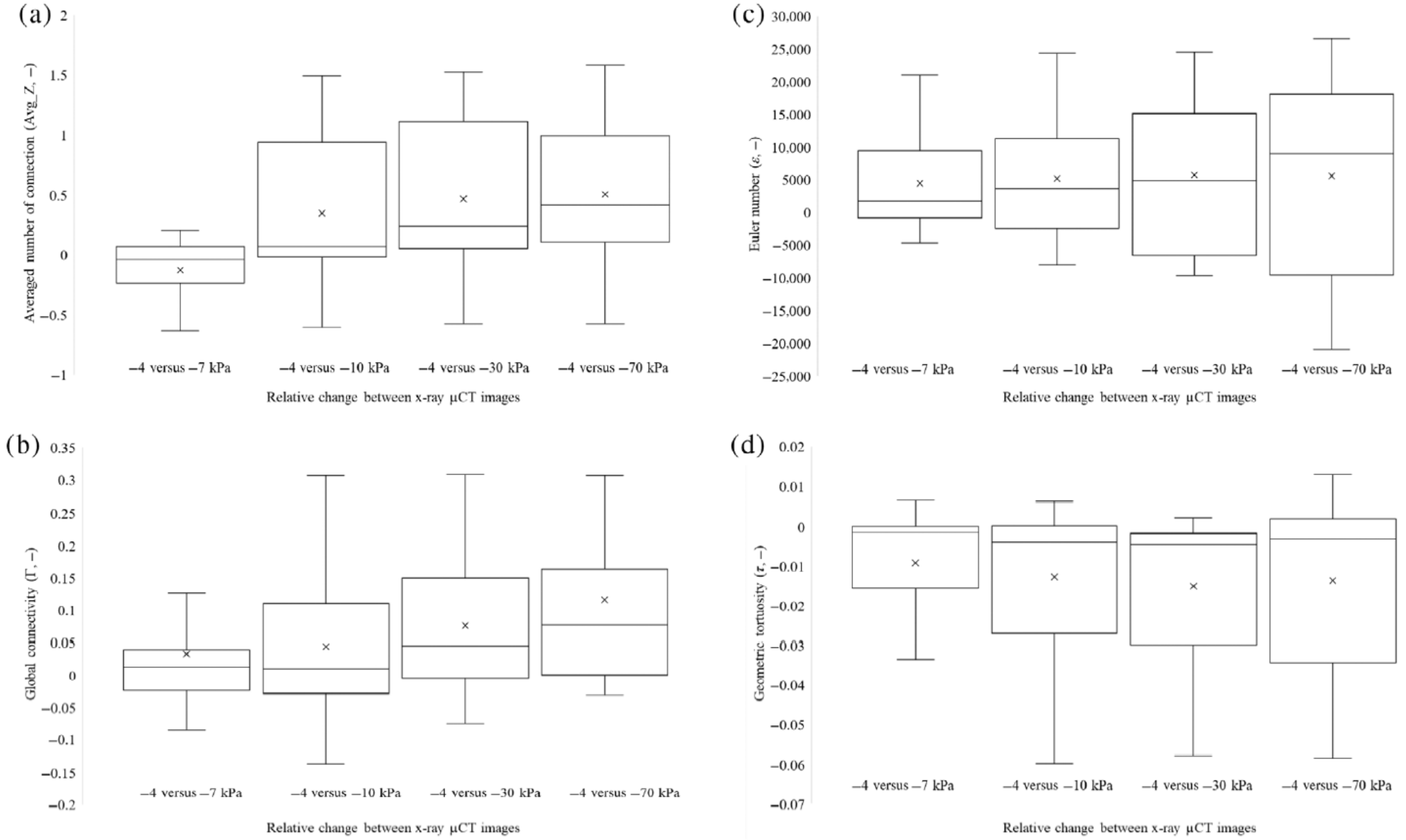


Results: from a population perspective

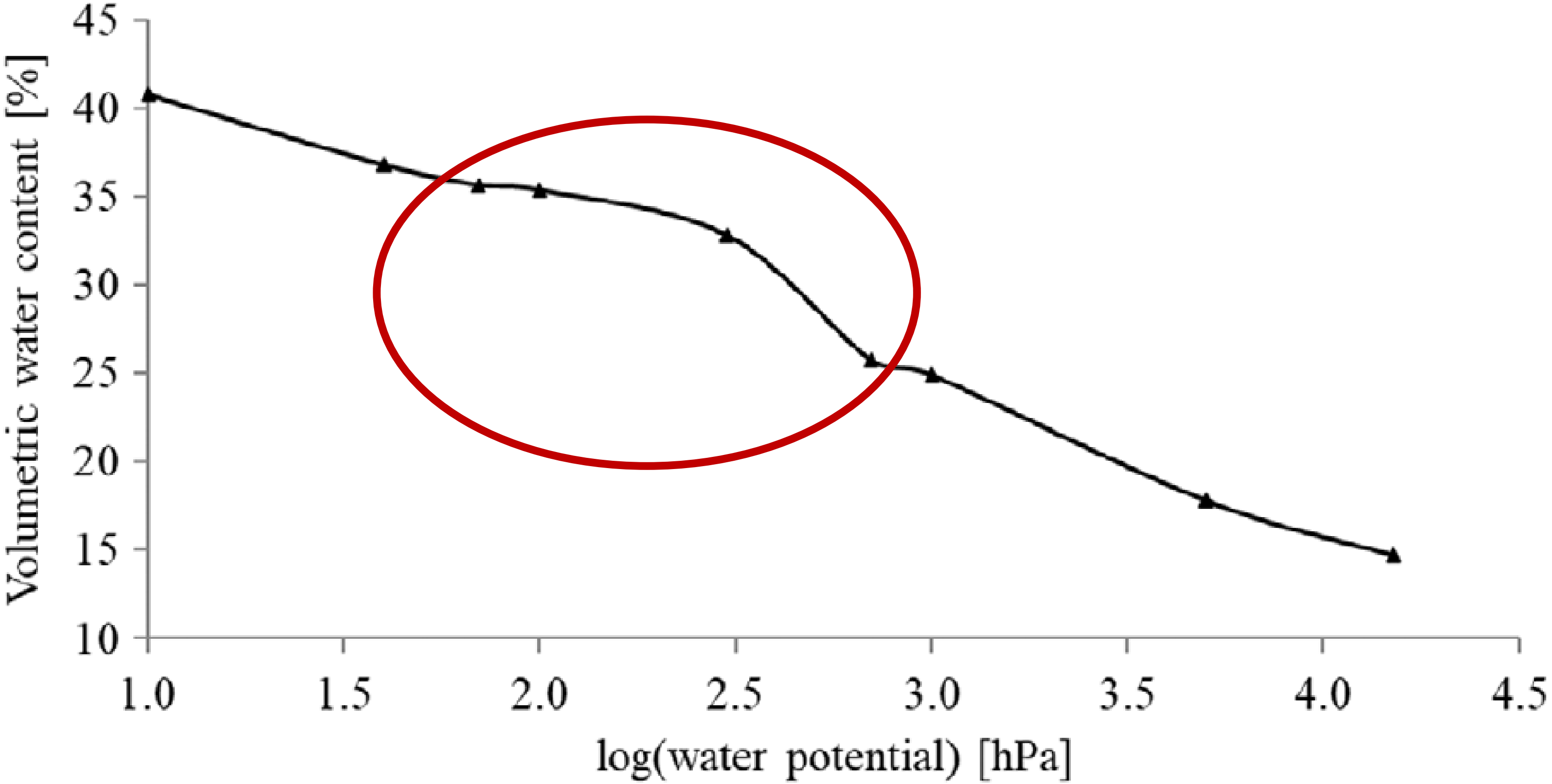


Results: from a population perspective

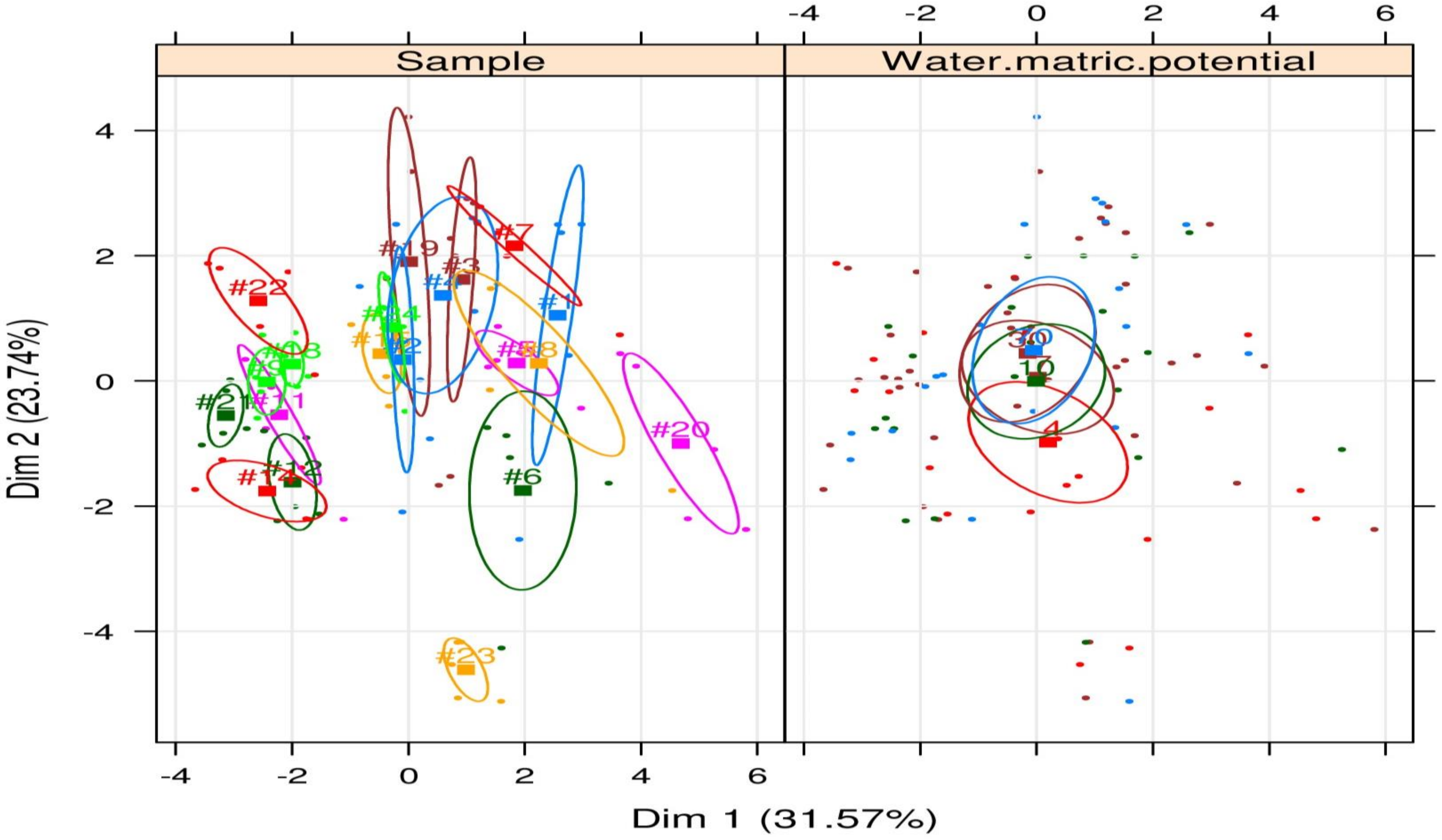
	Comparison between scans at water matric potential (kPa) of									
	4–7	**4–10**	**4–30**	**4–70**	**7–10**	**7–30**	**7–70**	**10–30**	**10–70**	**30–70**
µCT_PO	*	*	*	*			*	*	*	
ε			*	*						
FD		*	*	*			*			
τ	*	*	*	*						
Avg_Z			*	*	*	*	*			
SC										
Γ			*	*			*		*	

Results: from a population perspective

μCT_PO
ε
FD
τ
Avg_Z
SC
Γ



Results: from a population perspective



To conclude

- ➢Inter-sample differences, but intra-sample differences as well !
- ➢Sample-based analysis needed!

- ➢Capillary theory do not account for the pore space connectivity
- ➢And connectivity evolve as the soil desaturate…

- ➢Images analyzed at a rather coarse resolution (43 µm)

- ➢What’s next ?

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RESEARCH ARTICLE

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Characterization by X-ray µCT of the air-filled porosity of an agricultural soil at different matric potentials

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Abstract

To describe various important soil processes like the release of greenhouse gases or the proliferation of microorganisms, it is necessary to assess quantitatively how the geometry and in particular the connectivity of the air-filled pore space of a soil evolves as it is progressively dried. The availability of X-ray computed microtomography (µCT) images of soil samples now allows this information to be obtained directly, without having to rely on the interpretation of macroscopic measurements using capillary theory, as used to be the case. In

Thank you for your attention!

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