# A 3D VIEW OF NUTRIENT RECOVERY FROM RESIDUAL STREAMS

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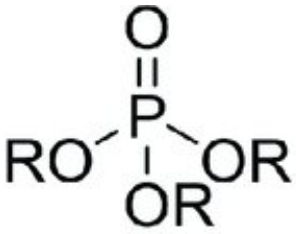
# A 3D view of nutrient recovery in the project ReAsh

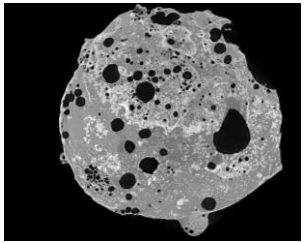
Overall assessment

System analysis




Elemental composition and crystalline compounds

P-K availability for plants and the mobility of P and toxic elements



Particle morphology, porosity and microstructure

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# ReAsh
## ELEMENTAL COMPOSITION AND CRYSTALLINE COMPOUNDS

- P-rich sludge ash fractions and reference samples from industrial processes
  - Biological sludge and bark
  - Mixed (bio and fibre) sludge and bark
  - Sewage sludge and wheat straw
  - Sewage sludge and sunflower husk
  - Sewage sludge and soft wood
- Characterised with respect to elemental composition (SEM, ICP…)
- Crystalline compounds investigated with XRD

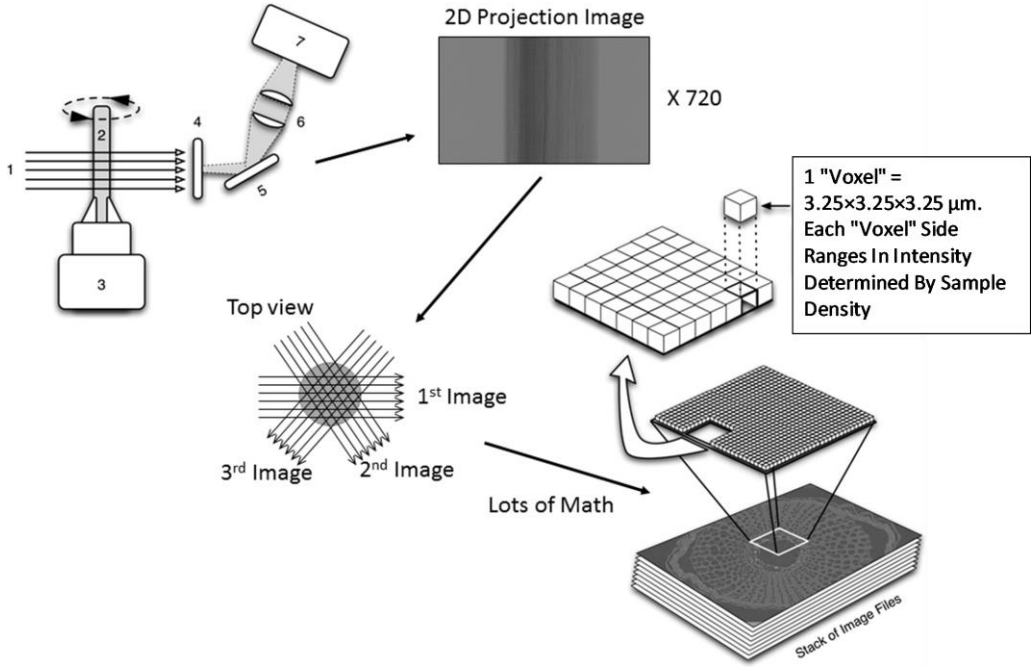
# ReAsh
## P-K AVAILABILITY FOR PLANTS

- P-AL leaching method
  - Determination of available phosphorus concentrations
  - Determination of leachable element concentrations
- Plant experiments
  - Dwarf beans during 4 weeks
  - No nitrogen restriction

# ReAsh
## PARTICLE MORPHOLOGY, POROSITY AND MICROSTRUCTURE

- X-ray tomography at LTU
- BET surface analysis at RISE-ETC
- Investigate how the process parameters and fuels impact the morphology
- Does these parameters influence leaching properties?

# X-RAY MICRO-TOMOGRAPHY




1. X-ray source
2. Sample
3. Rotating sample holder
4. Crystal scintillator
5. Mirror
6. Lenses
7. CCD-camera

McElrone et al. Using High Resolution Computed Tomography to Visualize the Three Dimensional Structure and Function of Plant Vasculature, Journal of Visualized Experiments : JoVE, (2013) 50162.

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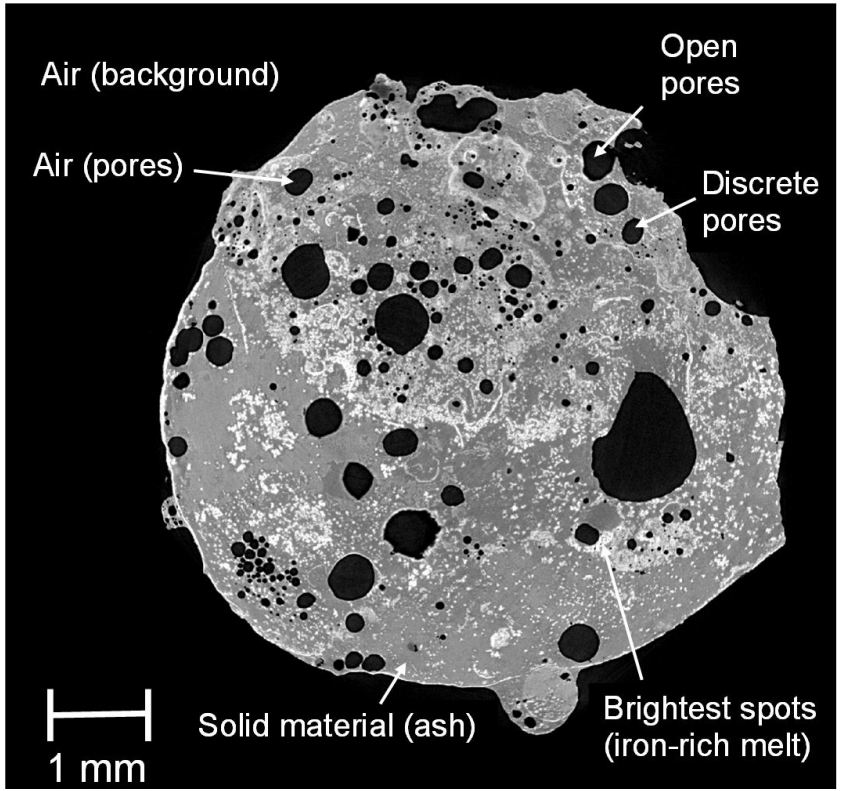
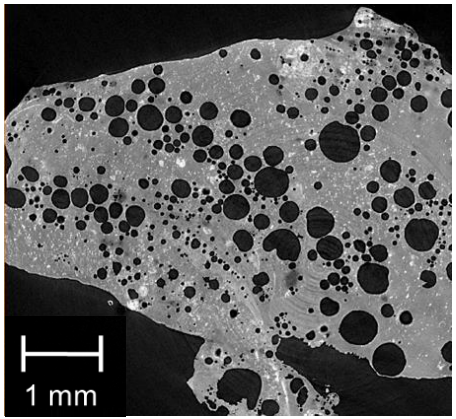
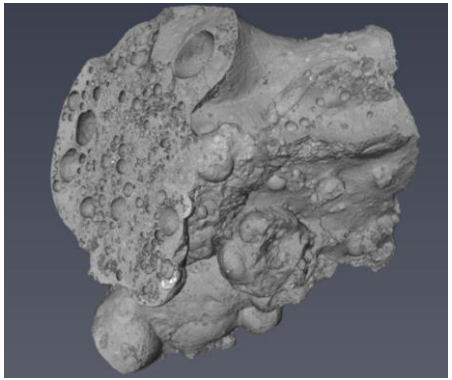
# X-RAY MICRO-TOMOGRAPHY

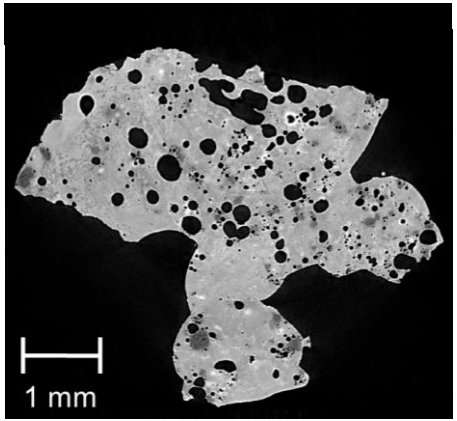


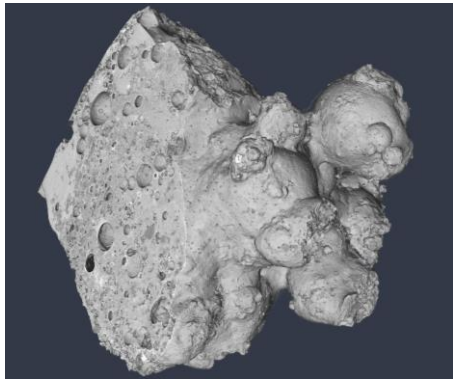
Bark 90%
Biosludge 10%



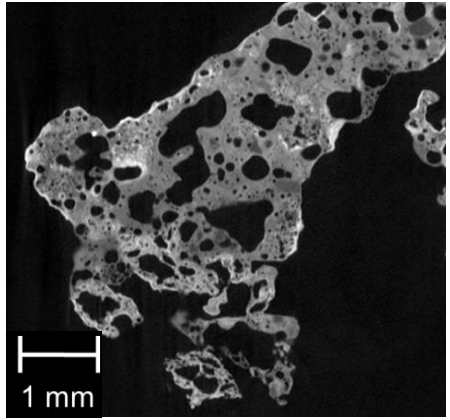



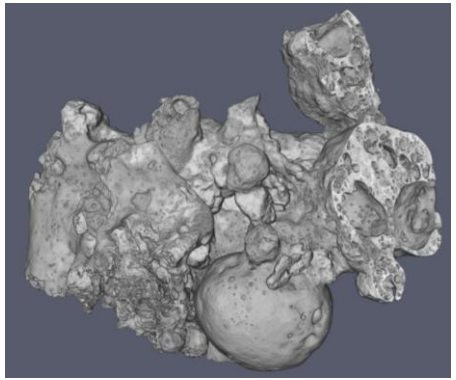
Bark 90%
Bio/fibre sludge 10%



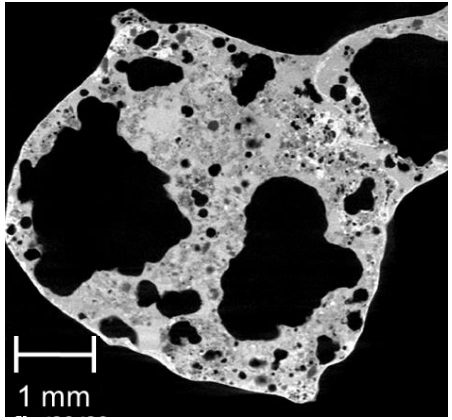



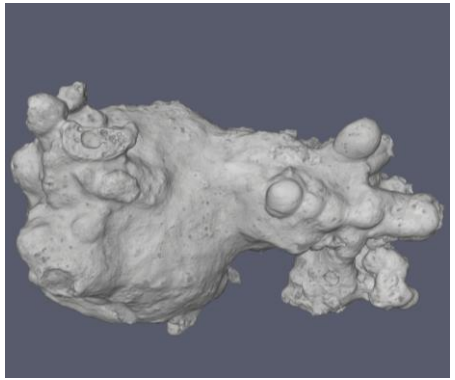
Wheat straw 90%
Sewage sludge 10%



Sunflower husk 85%
Sewage sludge 15%



# WHAT WE HAVE LEARNED

- A valuable tool for examining ash particles in 3D
- Provides detailed information on chemical heterogeneity, morphology and porosity
- Discrete and open pores can be distinguished on a micrometre scale
- Resolution matters, adapt to research question

# AI-ASSISTED DEEP LEARNING ON TOMOGRAPHY DATA

- Highlight the potential of integrating microscopy techniques with machine learning to gain insights into complex materials
- In-deep characterisation of particles
- Streamline data analyses
- Develop methods to investigate distribution of phosphates and other crystalline phases in 3D
- Post-doc project funded by Kempe Foundations

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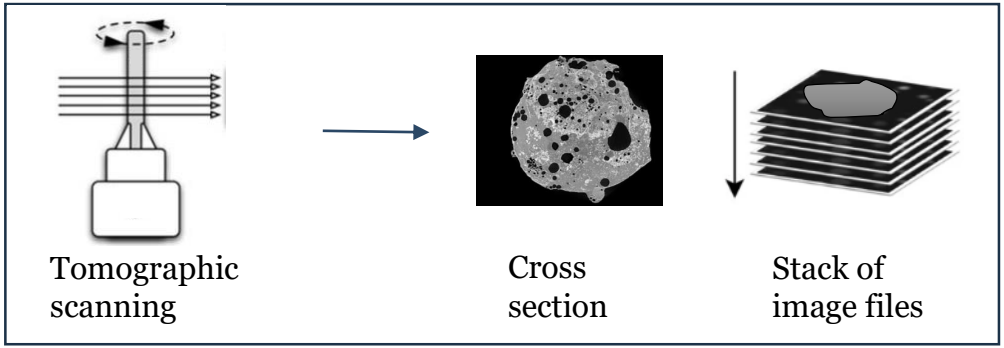
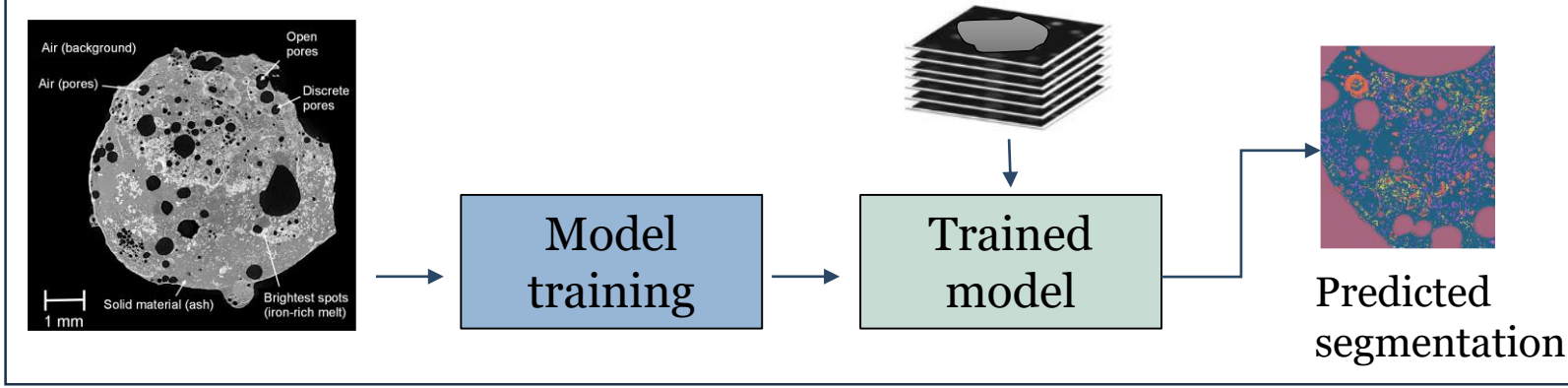
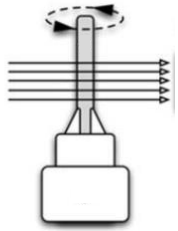
# AI-ASSISTED DEEP LEARNING ON TOMOGRAPHY DATA

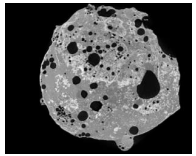


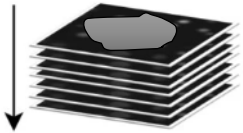
# FUTURE PLANS



Thomographic scanning
**+ 3D X-ray diffraction**

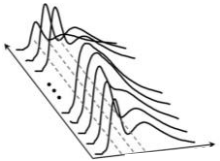


Cross
section

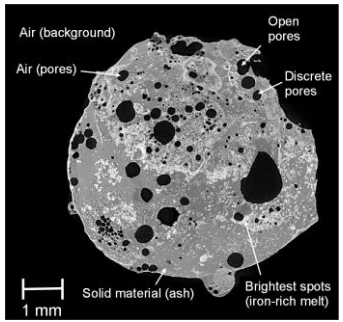


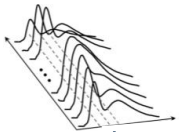
Stack of
image files

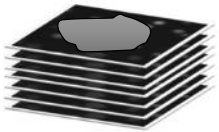
+



Spatially-resolved X-
ray diffraction profile





Model
training

Trained
model

Predicted
segmentation
+ distribution
of nano/micro-
crystal phases

# QUESTIONS?

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