Segmentation of X-ray tomographic images
contribution to weathering analysis of building limestones
originating from historical buildings

Emmanuel LE TRONG
manu@mixtion.org

IST Orléans
INSTITUT DES SCIENCES DE LA TERRE D'ORLÉANS

June 7, 2007
Cultural heritage in the Loire valley

*Château de Chambord*
The tuffeau building stone

SEM image of a tufteau sample, $\times 1000$. 

- Micritic calcite
- Sparitic calcite
- Opal spheres

50 µm
Weathering of building stones

Examples of alterations due to weathering

- granular disintegration,
- loss of crust,
- loss of scales, etc.

The idea: understanding the mechanisms of weathering via some physical model. Such a model requires a good description of the microstructure of the medium.
principle of X-ray tomography

Rotating object

X-ray beam

Light source

Scintillator & CCD detector

Filtered back-projection algorithm

Reconstructed slice
X-ray microtomography at the ESRF

*The European Synchrotron Radiation Facility, Grenoble.*
Example of image obtained

▶ One sample section over 2048,
▶ image is $2048 \times 2048$ pixels,
▶ pixel size is $0.27 \mu m$. 

200 µm
Example of image obtained

Zoom on the previous image (556×640 voxels).
Example of image obtained

3D sample, image is $1024 \times 1024 \times 2048$ voxels ($0.27 \times 0.27 \times 0.55$ mm).
How to extract the microstructure?

Extracting the structure of the image requires to identify the phases (calcite, silica and void), i.e. to segment the image. Each phase should be identified by its grey level in the image (which is connected to the X-ray absorption coefficient of the phase).
How to extract the microstructure?

*Histogram of the 3D image.*
How to extract the microstructure?

The images are noizy!
Impossible to segment as they are.
The method

Filtering → Gradient → Watershed → Mosaic

The image analysis method.
Results
Results

Histogram of the 3D original image & mosaic.
The 3D sample.
Results

The mosaic.
Results

The segmented image (calcite is yellow, silica is blue).
Results

The silica phase.
Results

The calcite phase.
Results

In this image, porosity is 34.2%, calcite is 38.3%, silica 27.5% (in vol.)
Results

Another sample.
In this image, porosity is 35.5%, calcite is 37.9%, silica 26.6% (in vol.)