Imagerie 3d des milieux cellulaires : de la morphologie aux propriétés effectives

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Imagerie 3d des milieux cellulaires : de la morphologie aux propriétés effectives

Objectif : Design de matériaux à propriété choisie

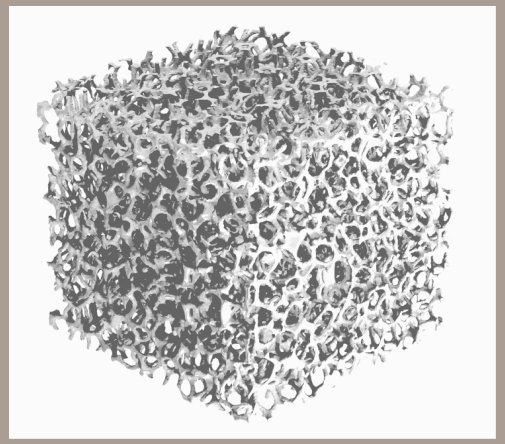
Problématique : établir des loi de propriétés en fonction de paramètres de structure

- mesurer des paramètres de structure
- identifier les paramètres pertinents pour une propriété choisie

Obtenir la propriété (mesure, calcul) pour des échantillons possédant des paramètres structuraux différents

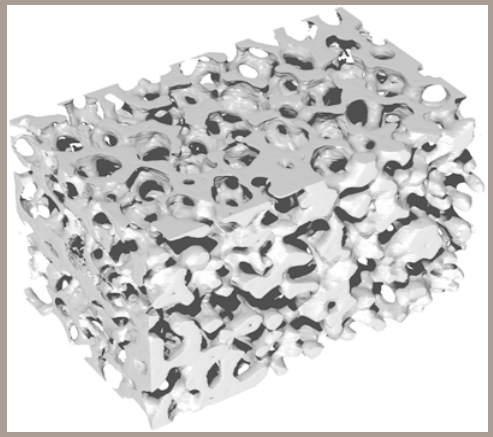
Applications aux mousses métalliques

Imagerie 3d des milieux cellulaires : de la morphologie aux propriétés effectives



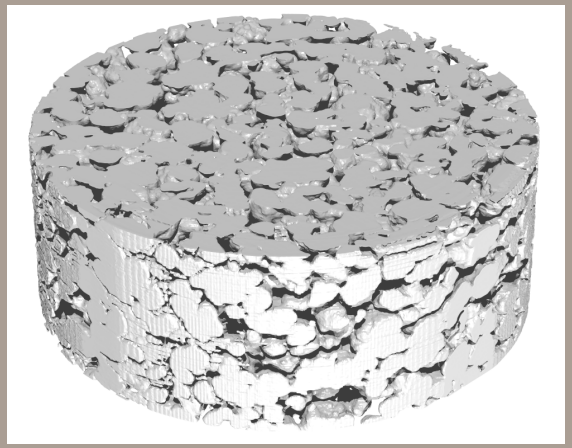
NiCr foams – Recemat (10,20,30,40,50,100 ppi)

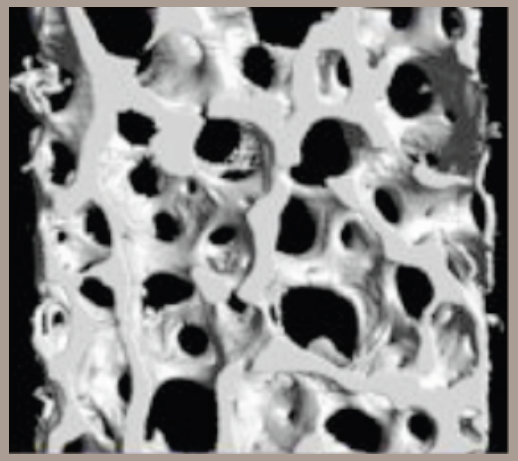
Al foams – ERG (5,10,20 ppi)



sic foams

sintered polyethylene balls (Porvair)





Trabecular bone (human)

Imagerie 3d des milieux cellulaires : de la morphologie aux propriétés effectives

- L'imagerie 3D des milieux cellulaires

- la question du Volume élémentaire représentatif
  - Ver géométriques
  - Ver de propriétés

- les propriétés effectives
  - Lois d'écoulement
  - Conductivité thermique
  - propriétés radiatives

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Our contribution/Domain

- **Fast Granulometry computing** — Fast implementation
  - Distance Map
  - Aperture Map
  - Maximal included balls
- **Advanced Morphology** — Original Methods
  - Automatic cell extraction
  - Local shape classification
- **Topology** — Original Methods
  - Squeltization
  - Cross section computing — Computational geometry
  - Tortuosity – minimal path extaction — Front propagation

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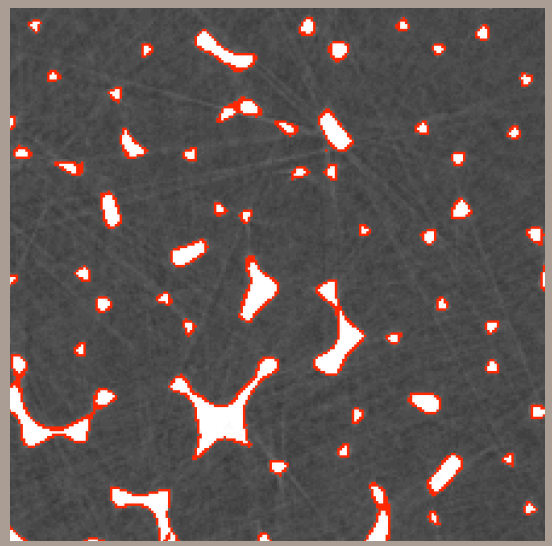
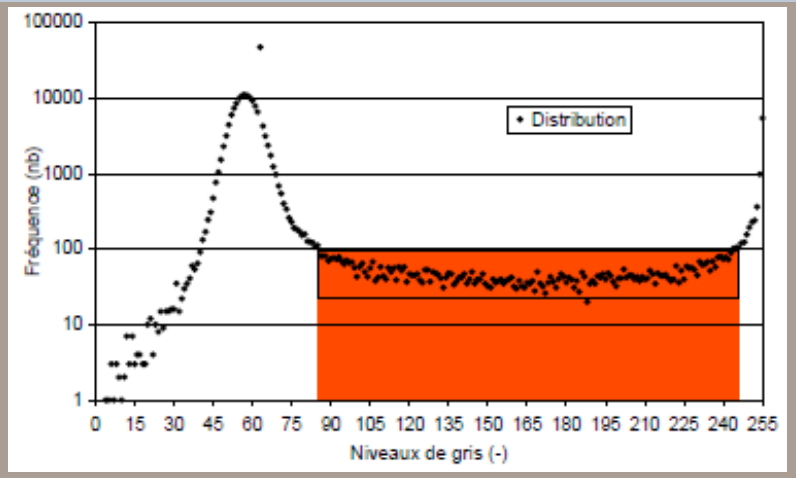
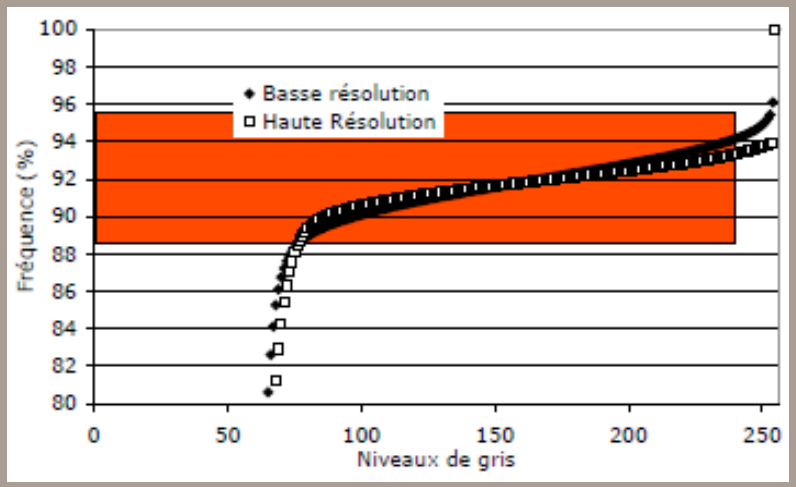
3D volume binarization

- Seuillage sur histogrammes de densité
- L'incertitude est a l'interface des deux phases



Localisation des voxels de la zone d'incertitude





Distribution cumulée

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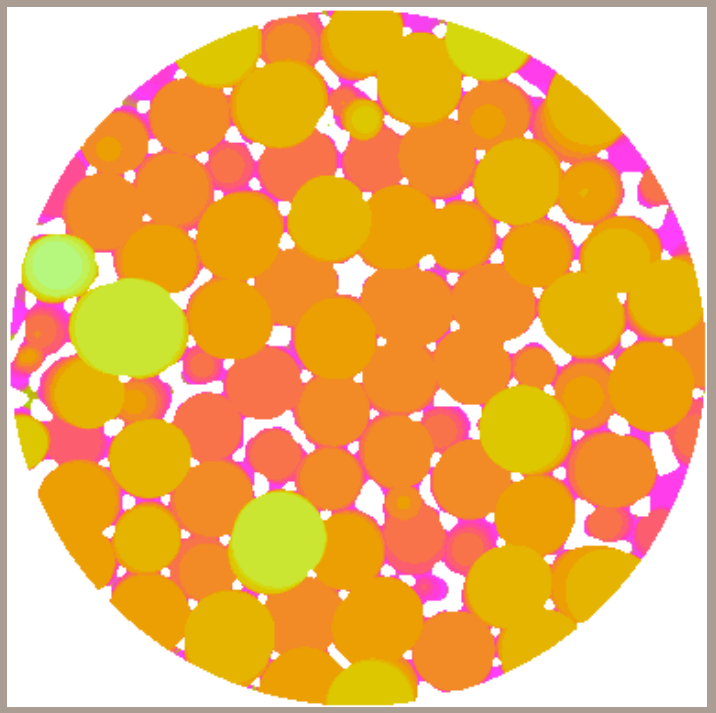
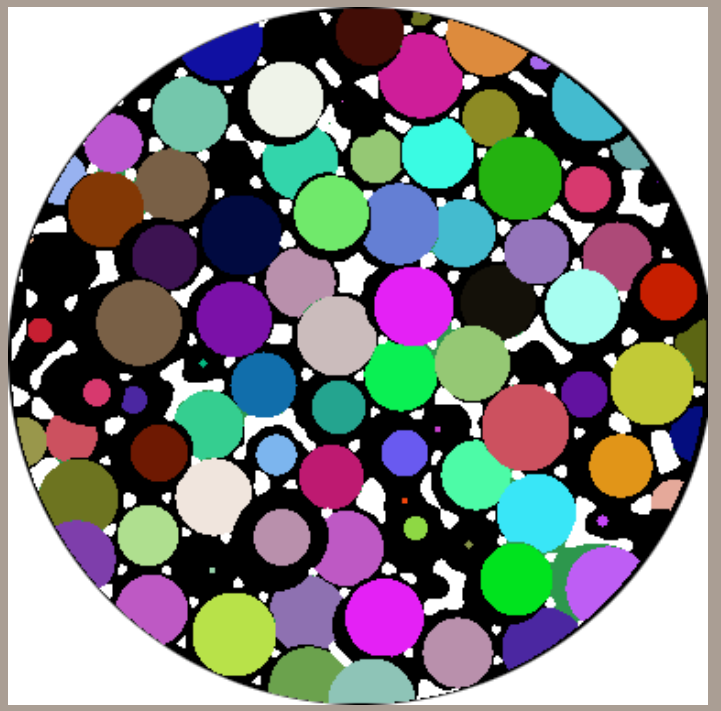
Fast Granulometry analysis

- Optimized algorithm permits a first evaluation of pore diameter
- Sphere totally included are extracted





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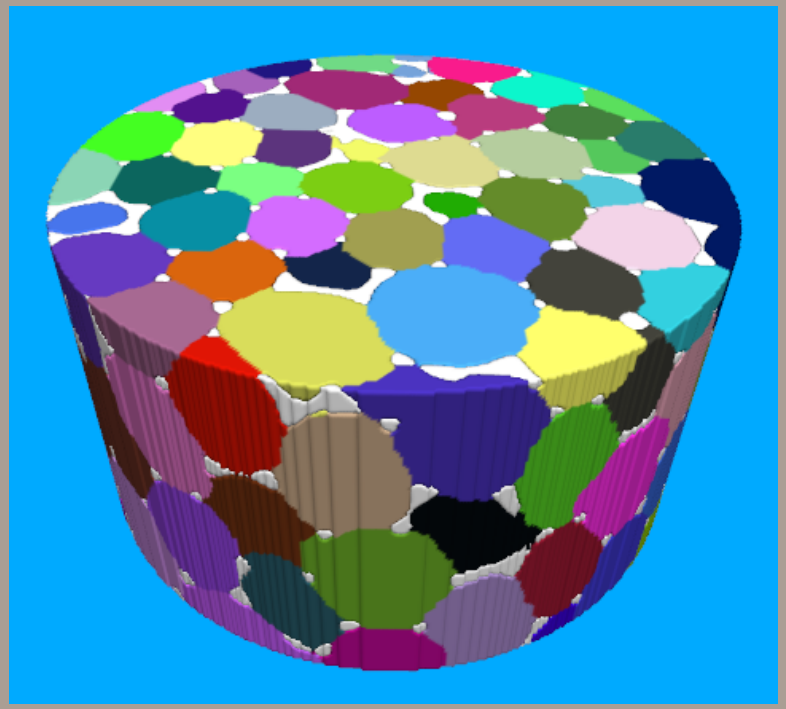
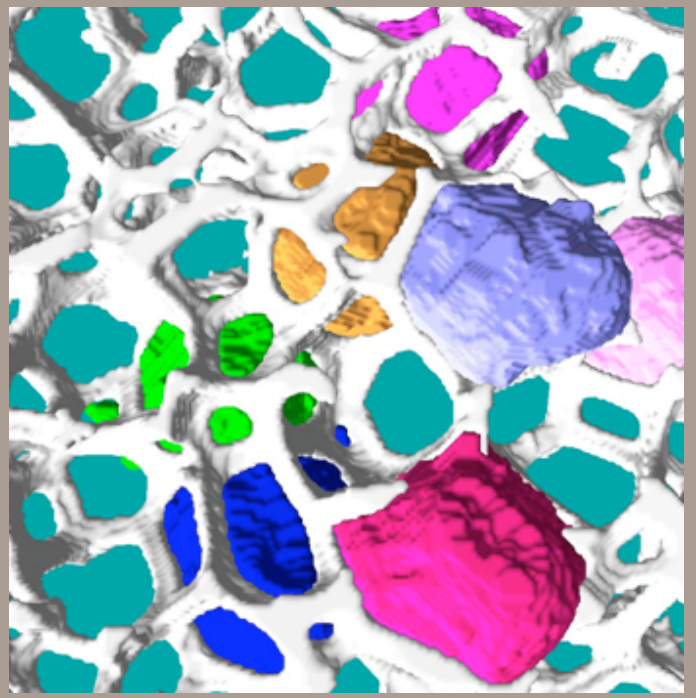
Automatic cell extraction (cavities)

- Unbiaised Watershed on distance map
- Markers are totally included ball





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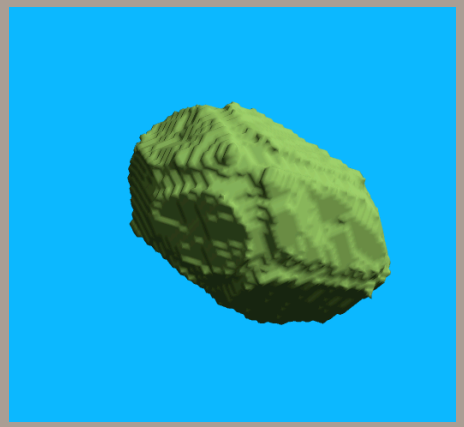
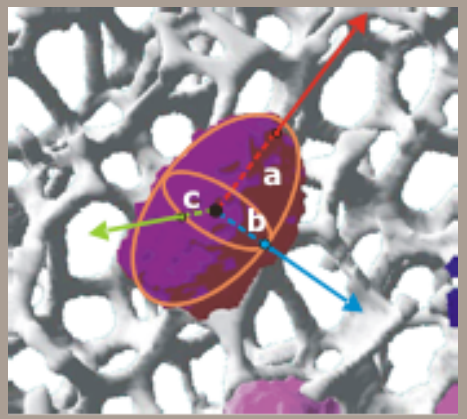
Cell Morphometry

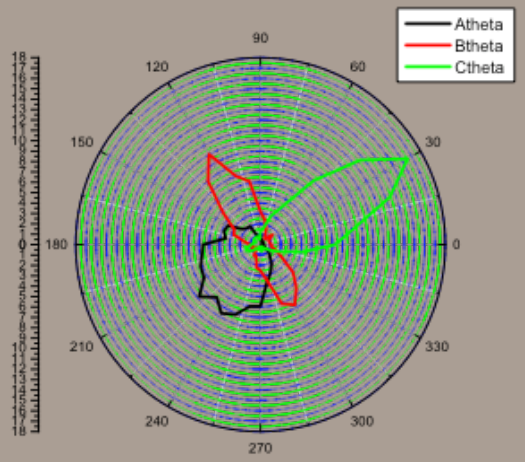
- Cells are ellipsoidic
- They have preferential orientations



Extracted cell



Equivalent ellipsoid



Orientation distribution

Inertia matrix of the voxels gives cell main orientations and sizes

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Local Shape Classification

Goal :

Identify directly on the solid matrix local spherical or plate or rode objects

Idea :

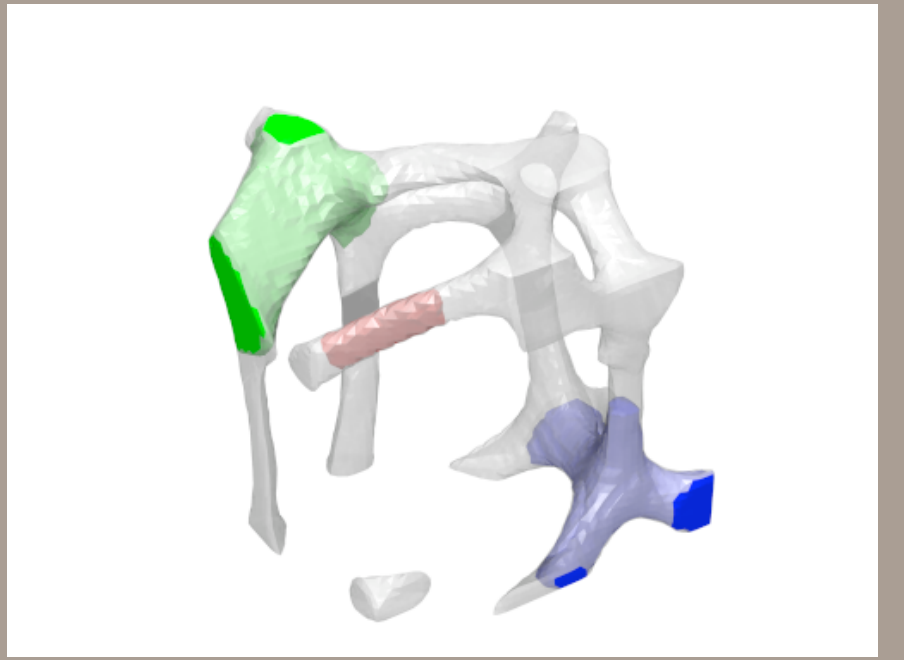
Local study of connected voxels

Method :

Propagate by a local front (fast marching)

The propagation depends on local diameter

Inertia matrix study of objects propagated



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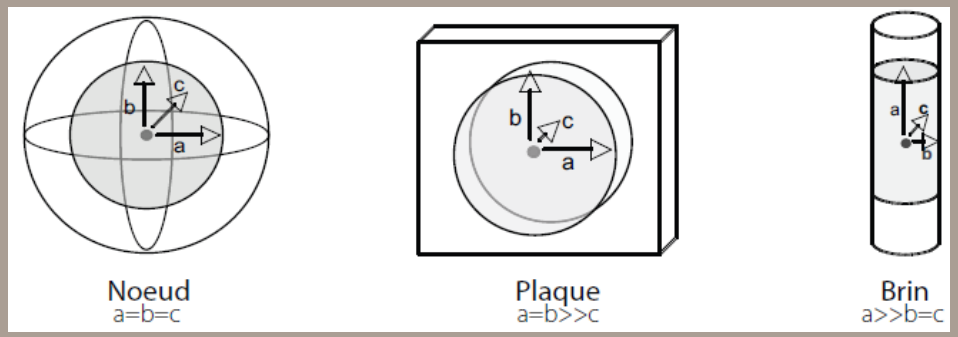
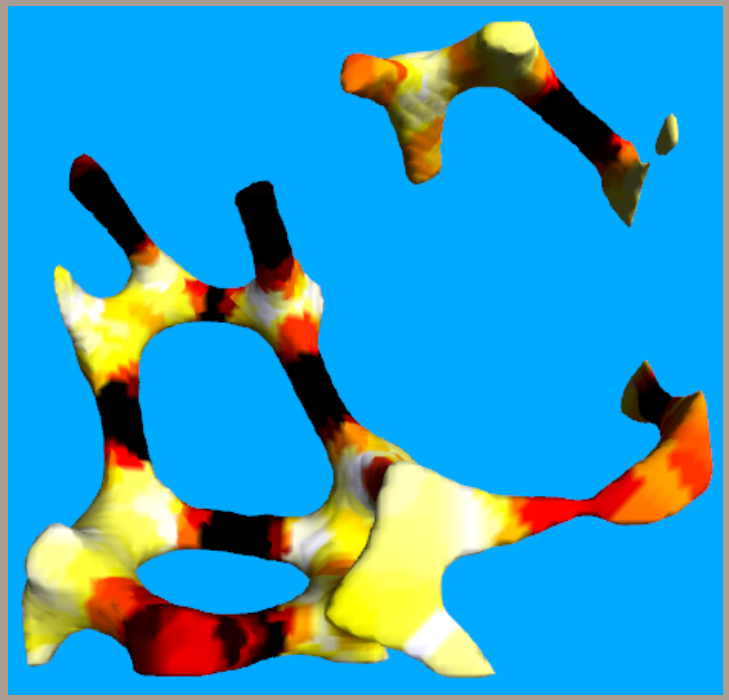
Local Shape Classification : Results



Node : a=b=c
Plate : a=b>>c
Strut : a>>b=c

The propagation diameter is 3x the local diameter (aperture solid diameter)



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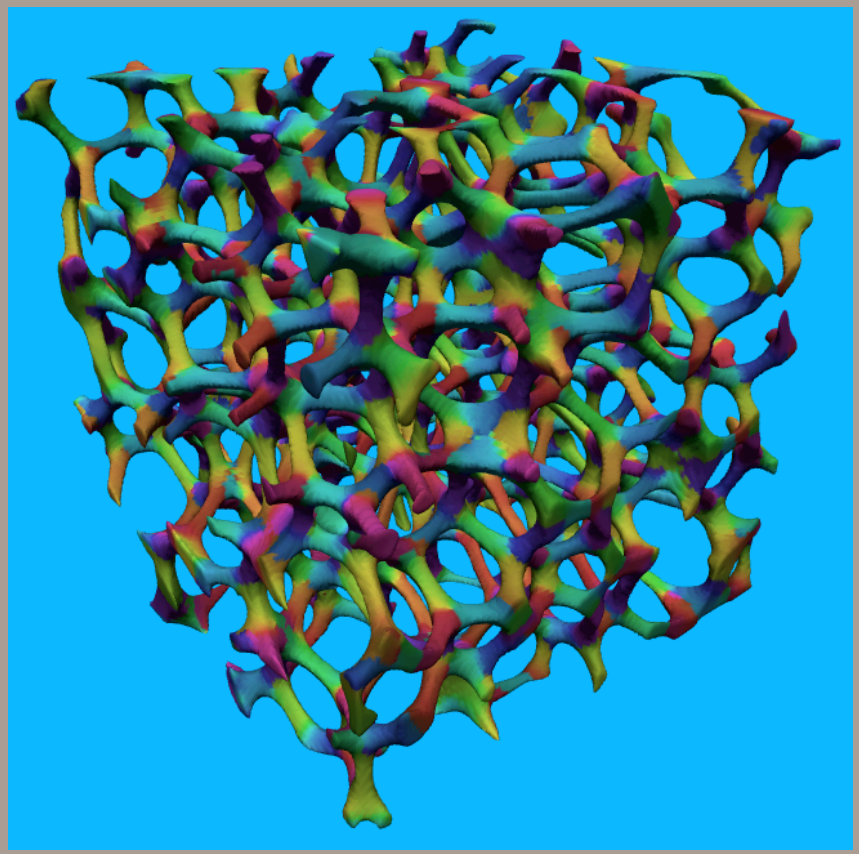
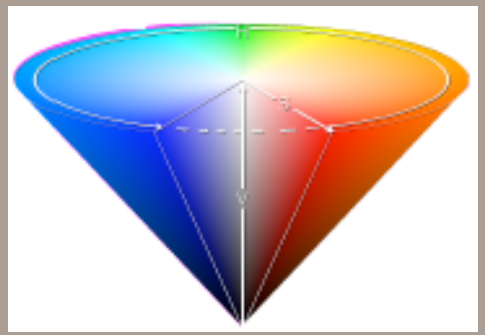
Local Shape Classification : Orientation of local shapes (colored orientation)



Local orientation ⇨ Azimuth/Elevation

Espace de couleur tSV :

- Teinte : élévation du brin
- Saturation : azimut



color space HSV

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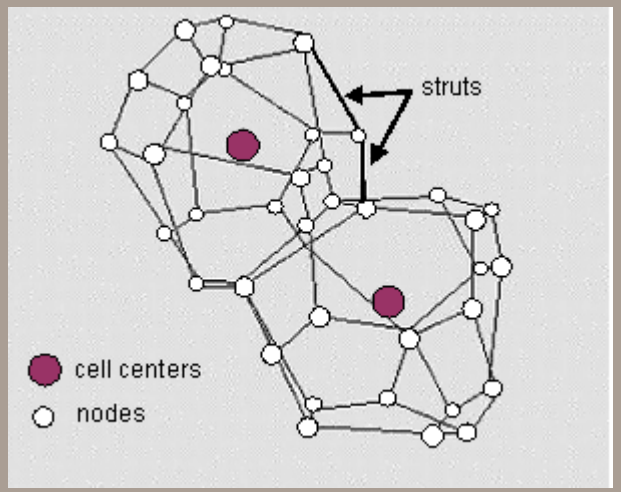
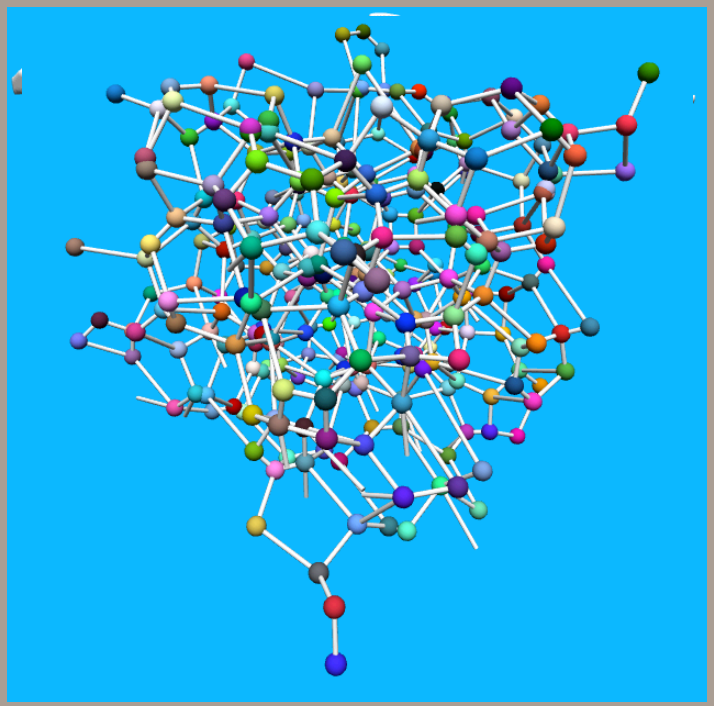
Squeletisation by Plateau's law :

node = 4 cells junction, strut = 3 cells junction, throat = 2 cells junction

Method : enflate previously segmented cells – isotropic dilation





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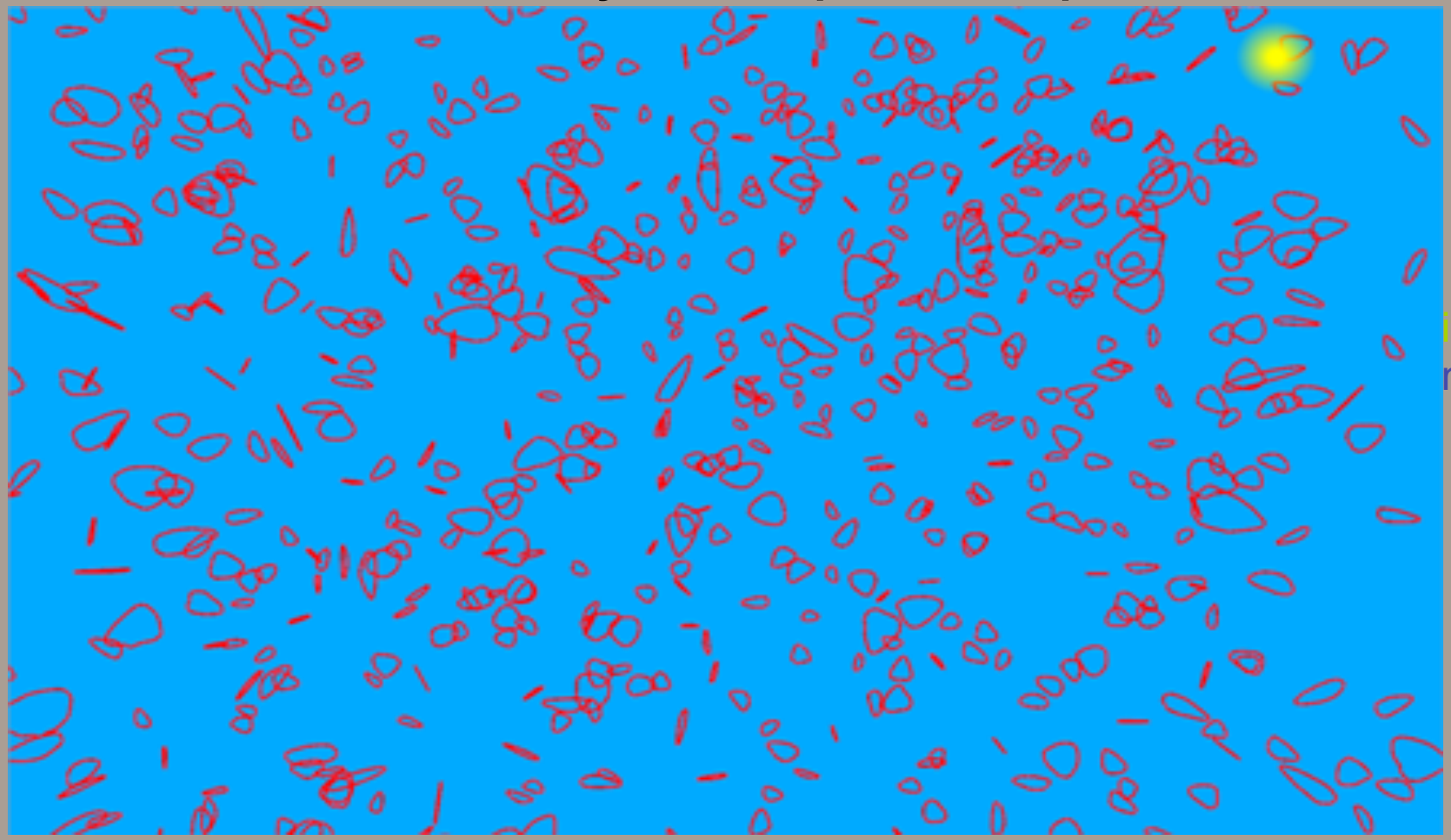
Struct cross section analysis from previous squeltization



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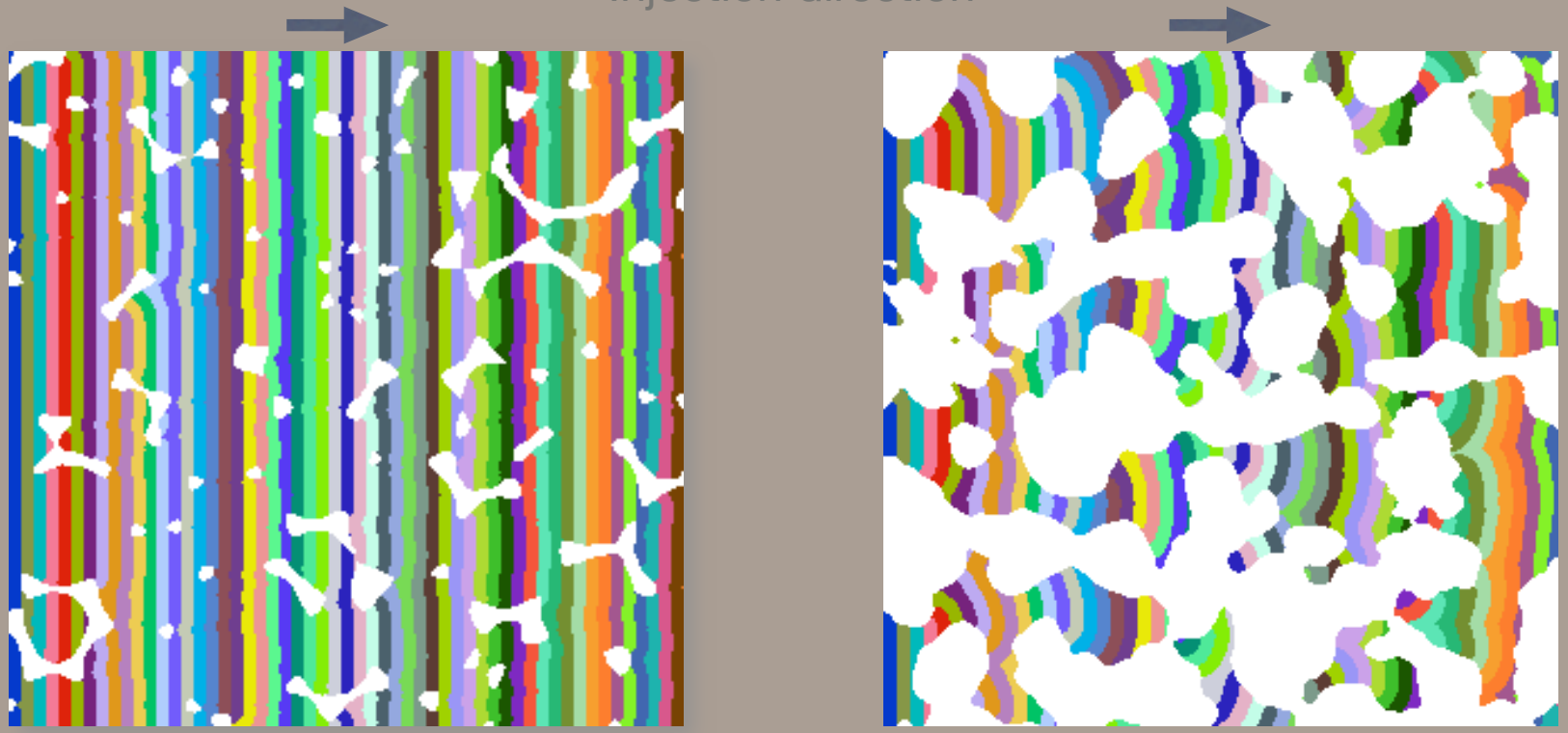
Tortuosity

Injection direction



ERG® AL FOAM

SINTERED POLYETHYLENE

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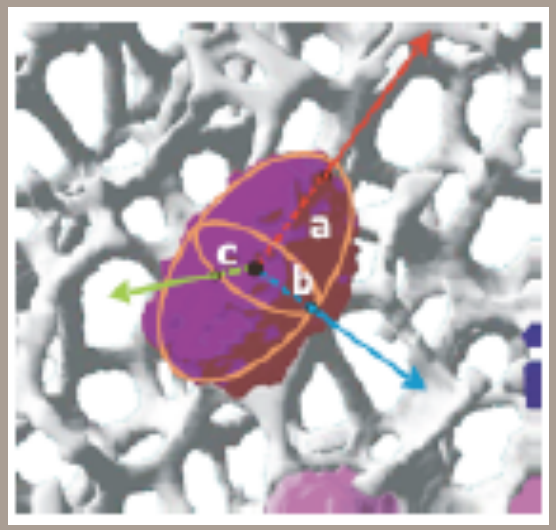
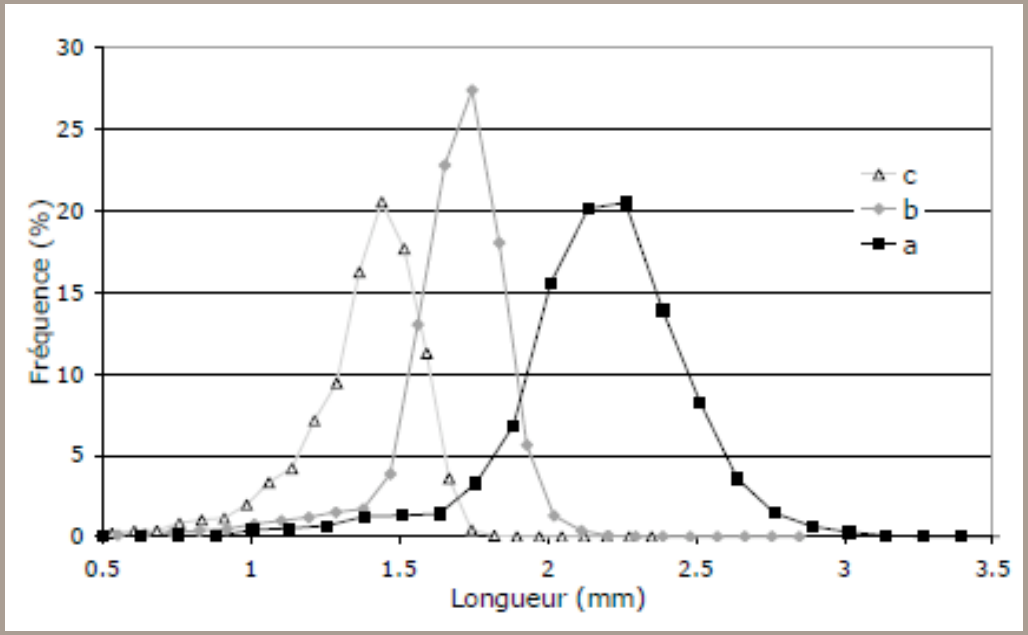
Quelques Resultas : Morphometrie des cellules

Mesure de l'ellipsoïde équivalent grâce à la matrice d'inertie de chaque cellule





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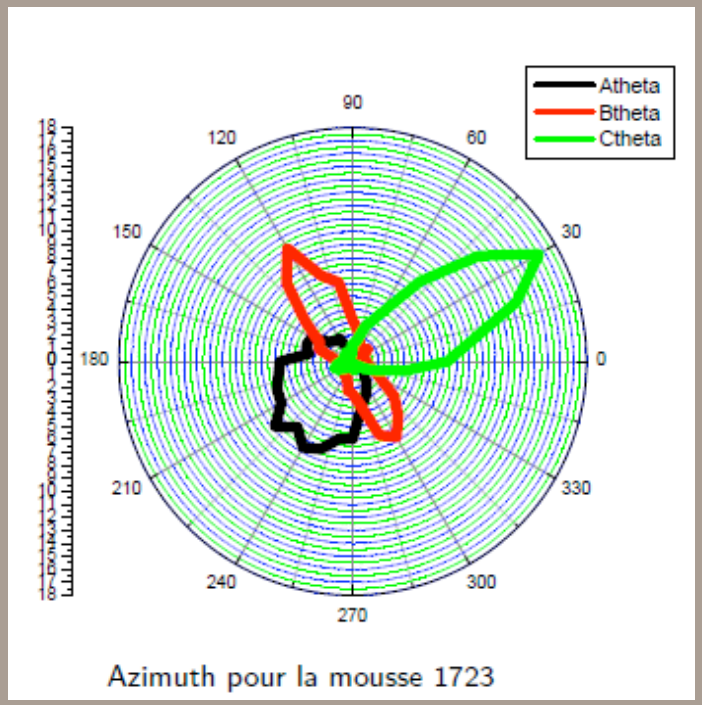
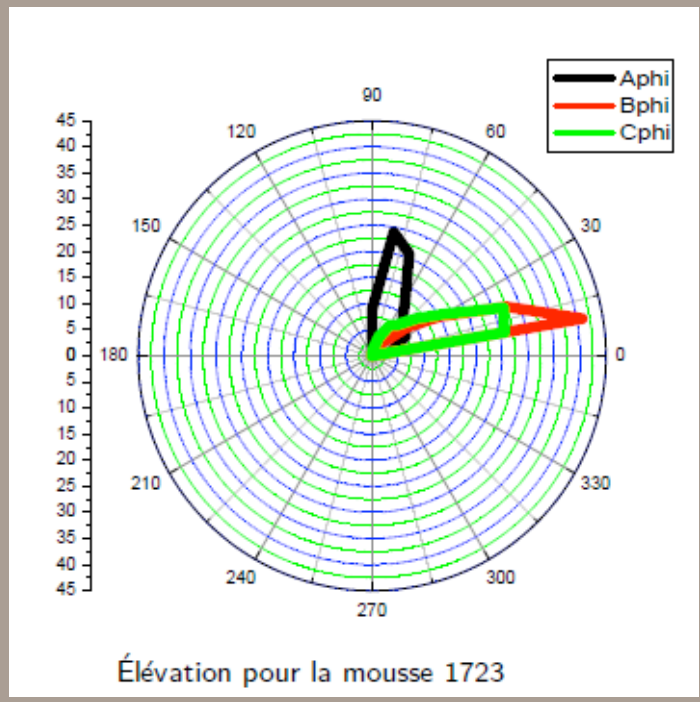
Quelques Resultas : Orientation des cellules



Azimuth pour la mousse 1723



Élévation pour la mousse 1723

- Les cellules sont organisées selon une direction privilégiée
- Distribution monomodale pour les 3 axes
- Le grand axe de l'ellipsoïde est dirige selon l'épaisseur

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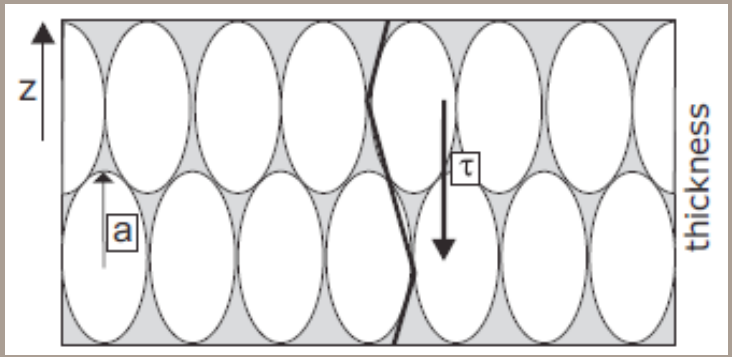
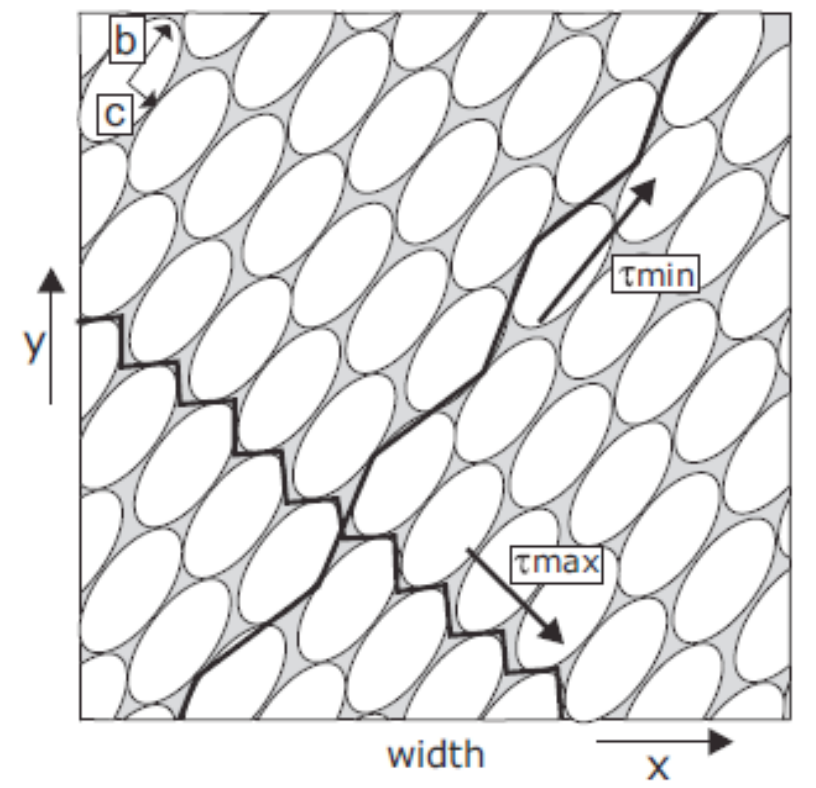
Quelques Resultas : Organisation des cellules





Cette organisation induit une anisotropie

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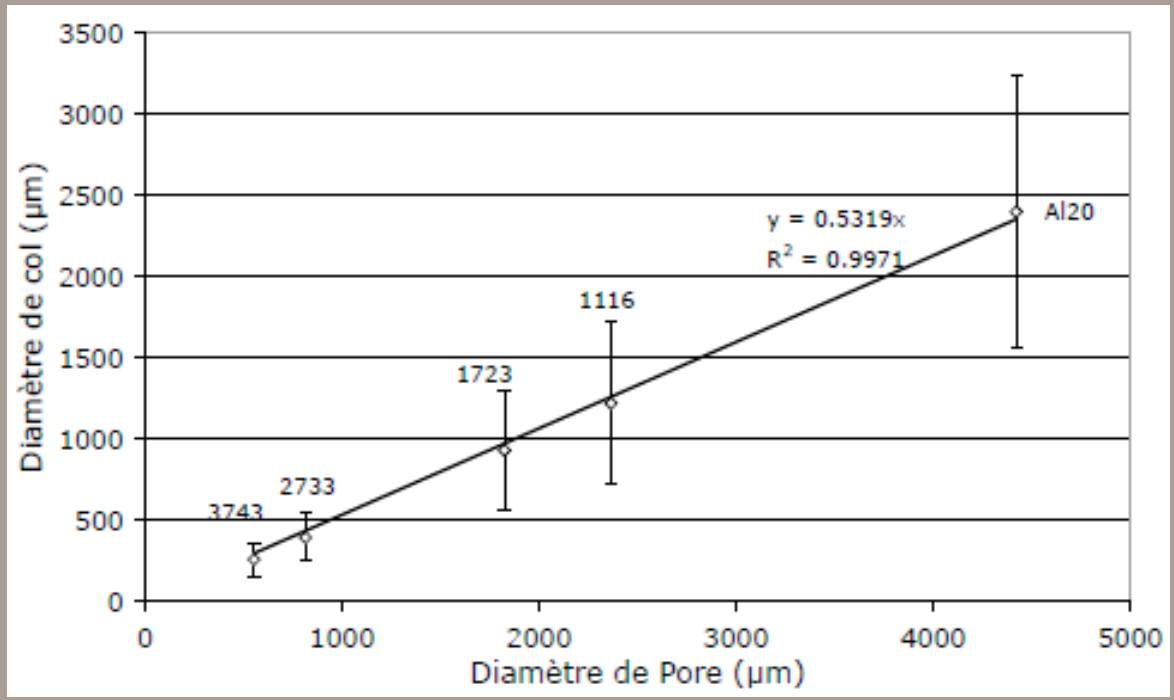
Quelques Resultas : Dépendance au diamètre de pore

Diamètres des cols

Dcol ≈ (1/2)Dpore



Mousses Recemat et ERG

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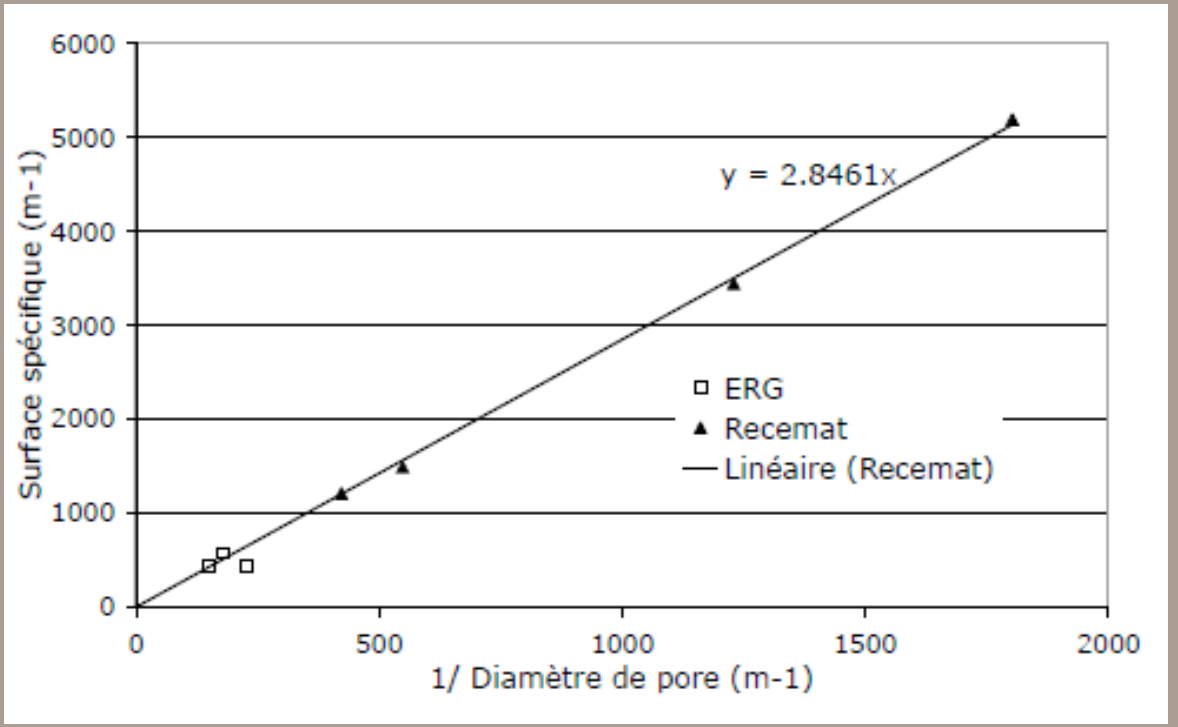
Quelques Resultas : Dépendance au diamètre de pore

Surface spécifique



Mousses Recemat et ERG

La surface specique est inversement proportionnelle au diamètre de pore moyen

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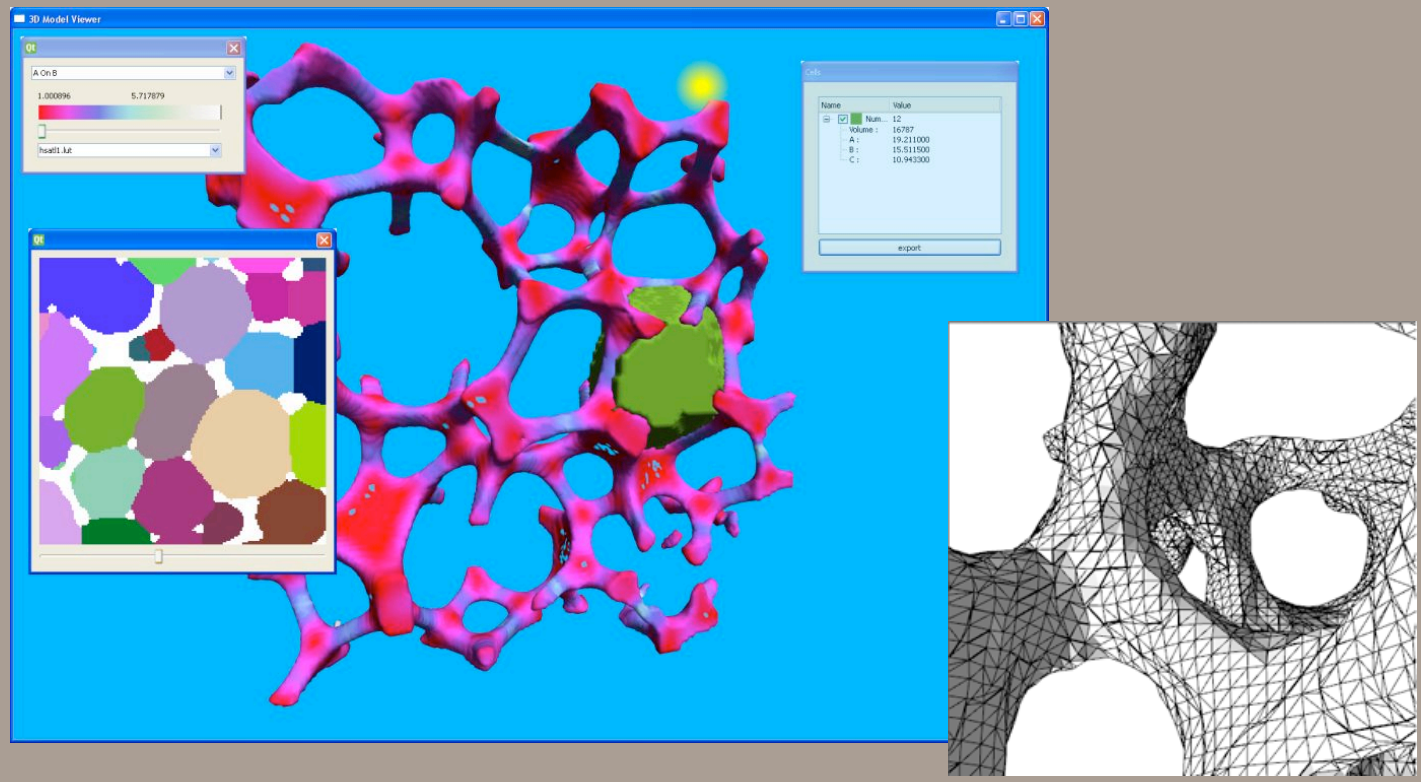
Surface rendering (house made marching cubes method)



Exportation des maillages vers codes de calcul CFD, thermique, ray-tracing

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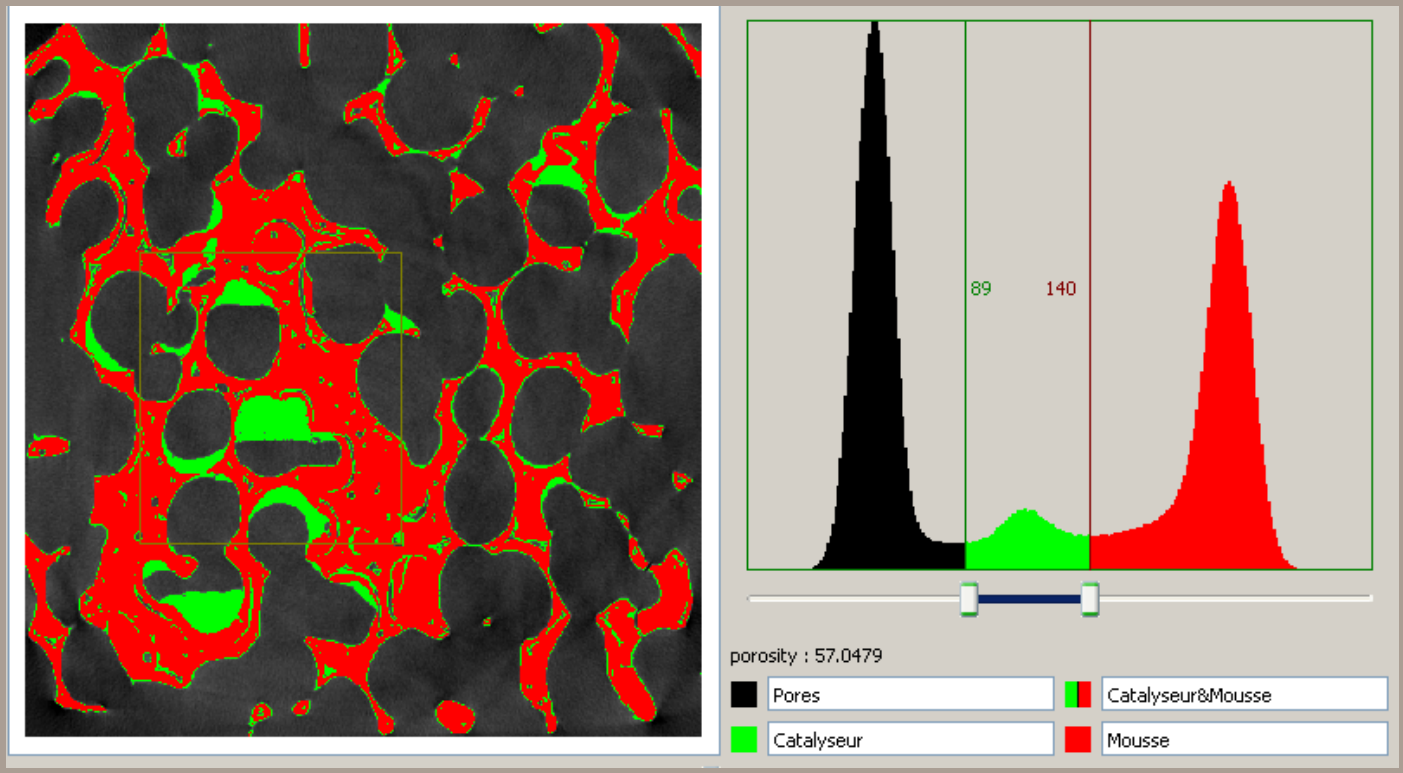
Multi Component analysis - MultiThreshold Phase identification



Catalytic deposit material

Application to filtration membranes

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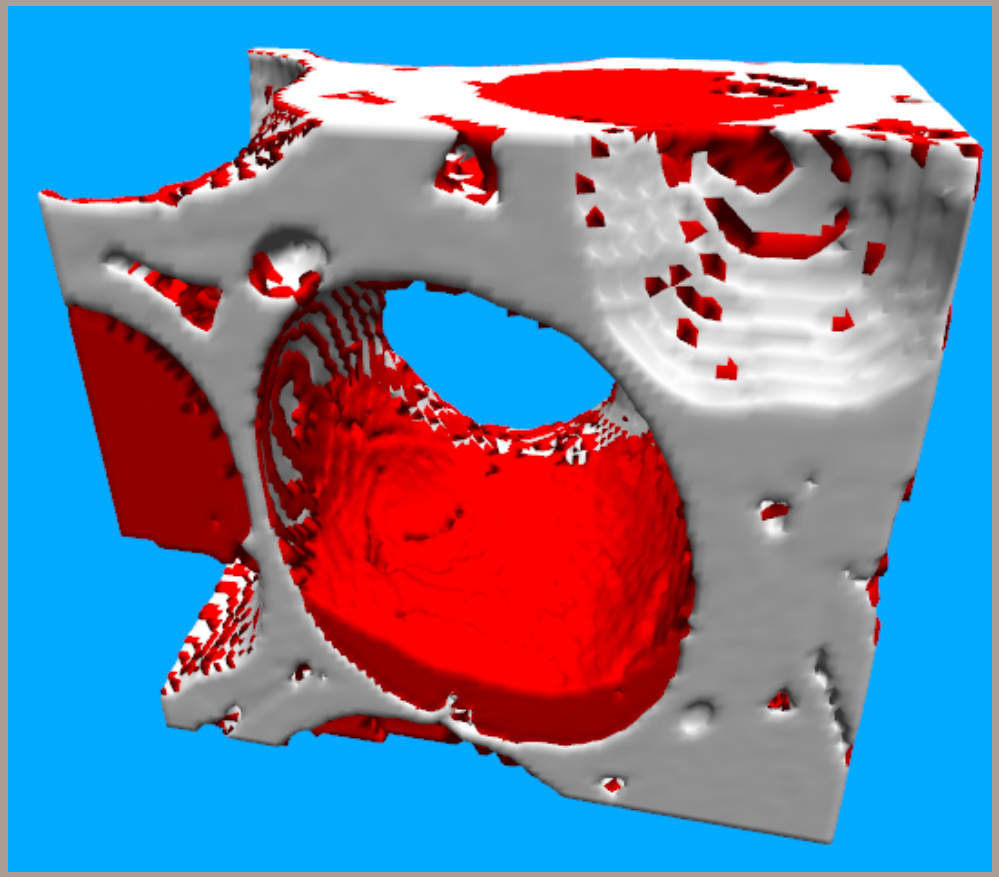
Multi Component analysis – multi Phase mesh managment



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iMorph : the Open Source Project

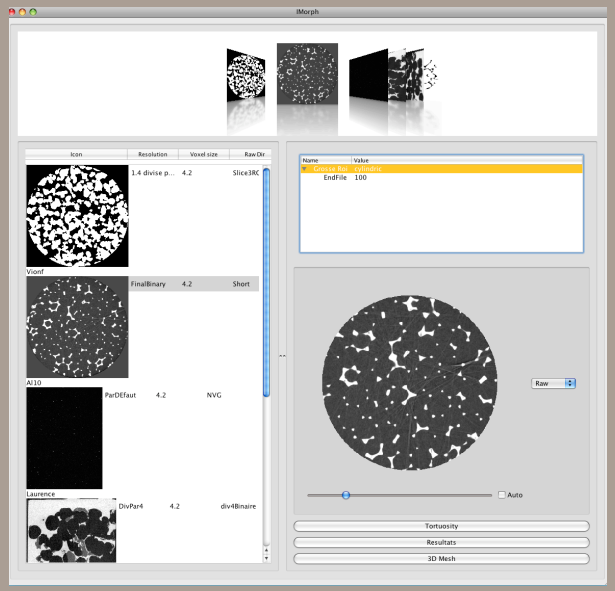
- Hébergé par SourceForge depuis le 10 juillet 2009
- 765 visiteurs uniques depuis le debut

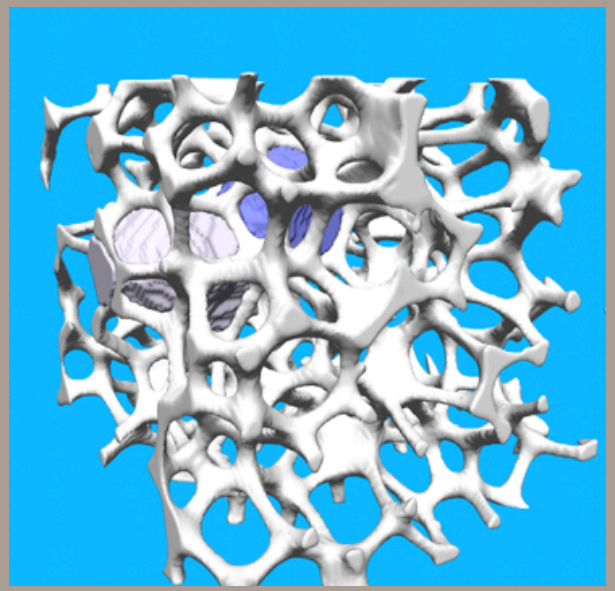
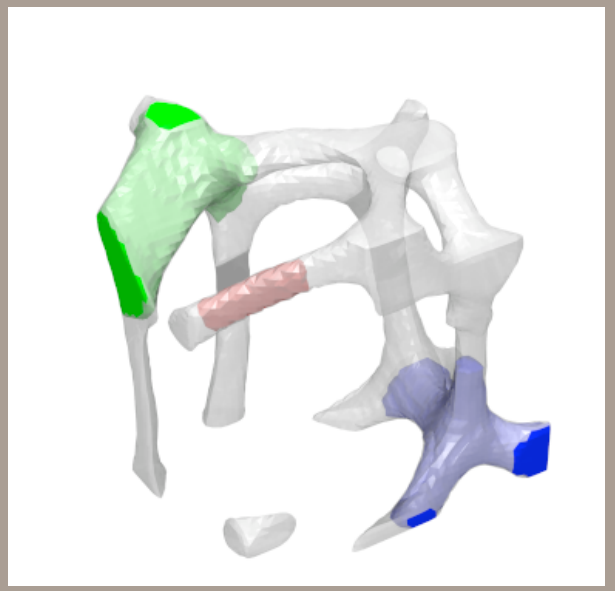
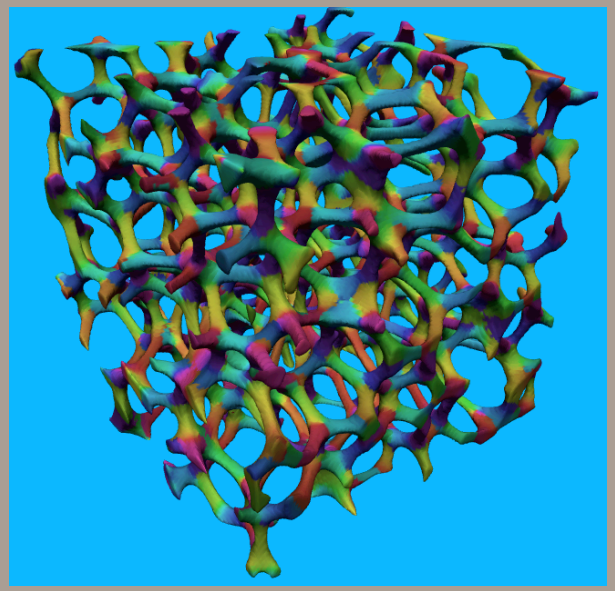
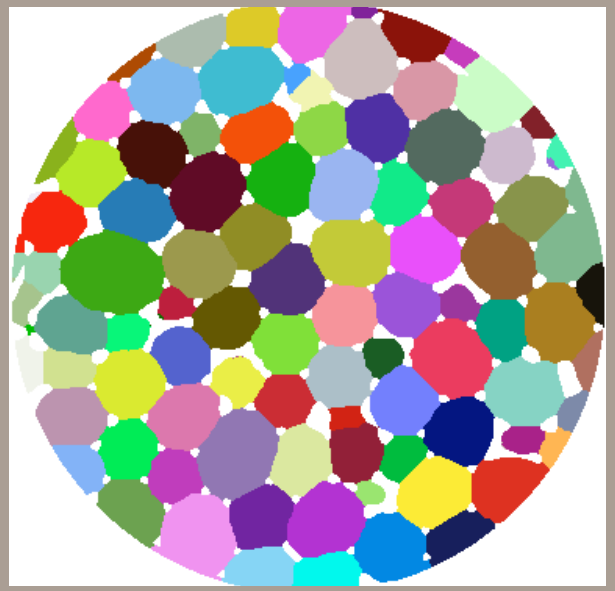
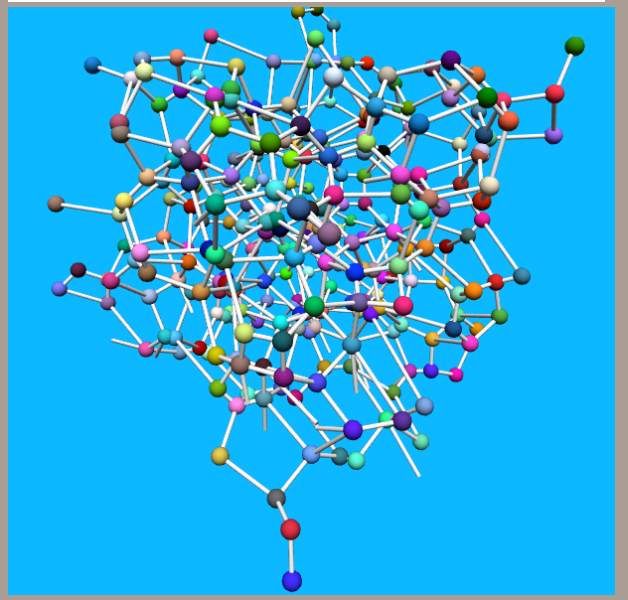
  Seulement 38% s'arretent à la première page
  Temps moyen sur le site 2min07

France	248
United States	130
Germany	71
United Kingdom	57
China	43

- 380 downloads

http://imorph.sourceforge.net



http://imorph.sourceforge.net

Conclusion

- IMorph permits the visualization and analysis of big 3D data volume.
- IMorph calculate Advanced morphometry, topological characteristics and geodesics of a material.
- open source project licence CeCill (CNRS/INRIA/CEA)

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Why opensource?

- We are developing our own software for 5 years. 7 international journal articles + 10 international conferences communications has been made with it.
- We are mainly 2 developpers/users and we want to enlarge it.
- We decide to deposit the software as an open source project. The licence is CeCILL (GPL compatible).
  - Get together the image science developper comunity
  - Modification of sources is possible for your specific needs
  - Free to use for non profit project