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SWISS GEMMOLOGICAL INSTITUTE
INSTITUT SUISSE DE GEMMOLOGIE

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New Developments in Pearl Analysis : X-ray micro Tomography and Radiocarbon ^{14}C Age Dating

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Pearls, pearls, pearls...



Cultured Pearls: The options

- Saltwater or freshwater
- Gonad grown or mantle grown
- Beaded or beadless



Limited combinations for CP's

Oyster saltwater	Gonad grown	beaded	Akoya, Tahiti, South Sea, etc.
Oyster saltwater	Gonad grown	beadless	"Keshi" head rejected
*Oyster saltwater	Mantle grown	beadless	New Type Baroque
Oyster saltwater	Mantle grown	beaded	not seen ? (Mabé)
*Mussel freshwater	Mantle grown	beadless	Biwa, Chinese freshwater, US
Mussel freshwater	Mantle grown	beaded	China freshwater coin, round
Mussel freshwater	Gonad grown	beadless	not seen ?
Mussel freshwater	Gonad grown	beaded	not seen ?



from H.A. Hänli, 2008

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Saltwater beadless cultured pearls.

- Gonad grown "Keshi" first generation

The bead is rejected just after implantation of the bead together with the mantle tissue (epithelium) into the gonads.
Usually round to button and drop shapes.



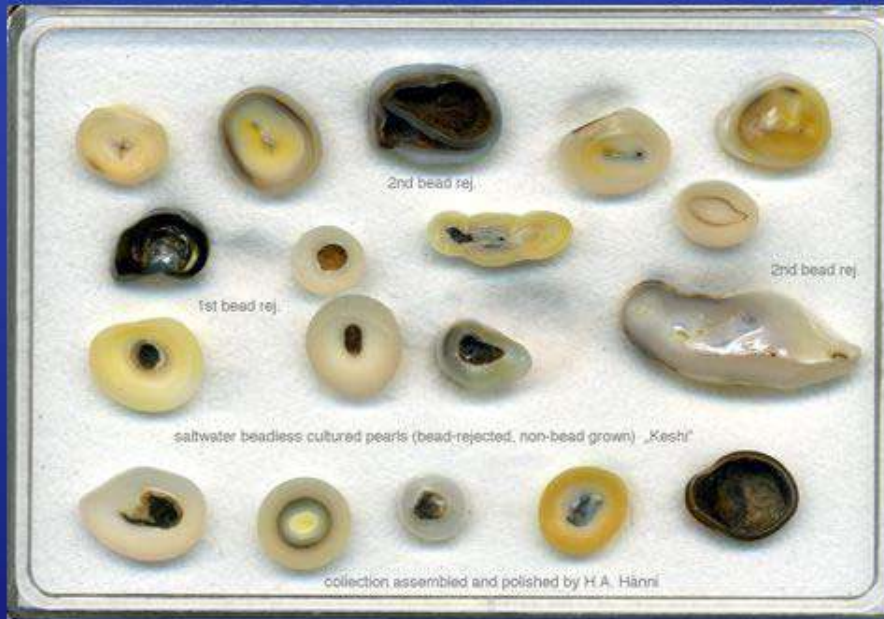
- Gonad grown "Keshi" second generation

After the first harvesting a second bead was implanted in the existing pearl sack, but shortly after was rejected.
The existing but collapsed pearl sack continues to produce nacre.
Usually baroque shapes.

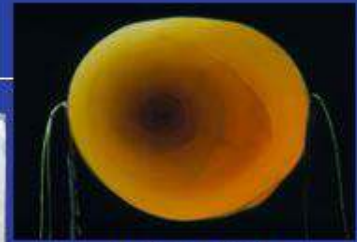


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Cross sections:



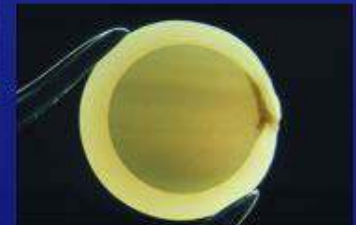
SW beadless cultured pearls



Natural pearl



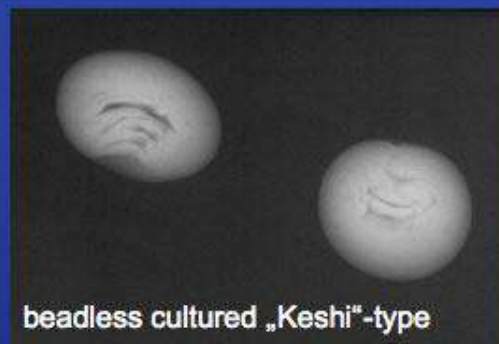
FW beadless cultured pearl



Beaded cultured pearl

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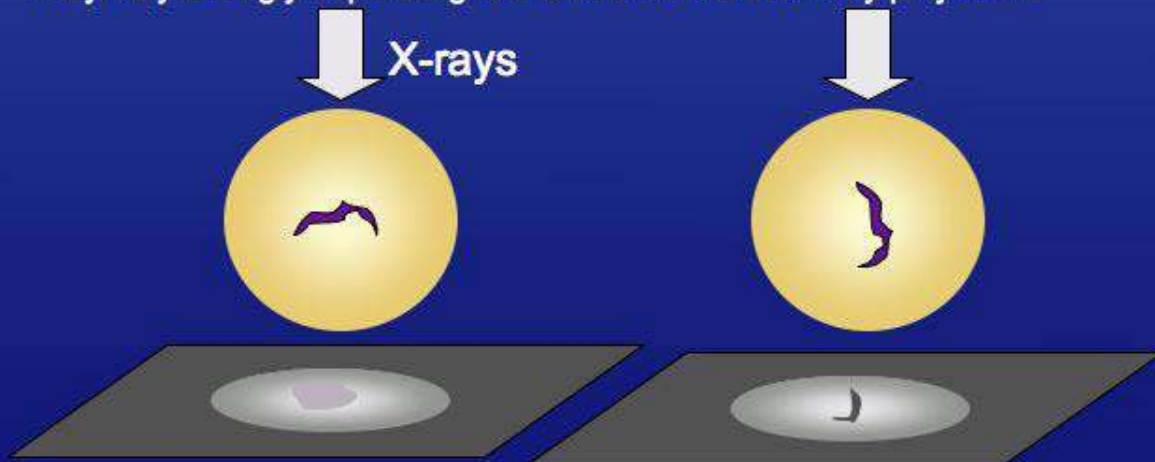
Radiography:



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Problems arising when interpreting radiographies

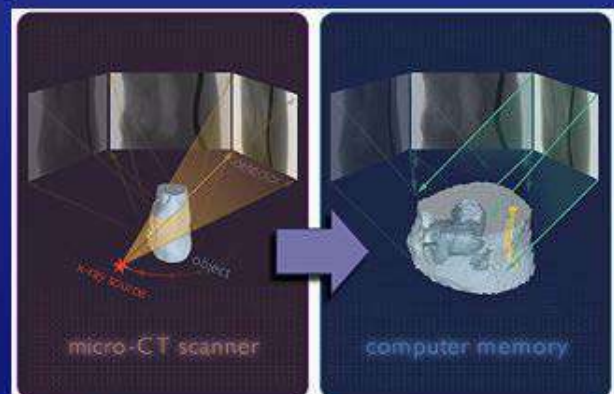
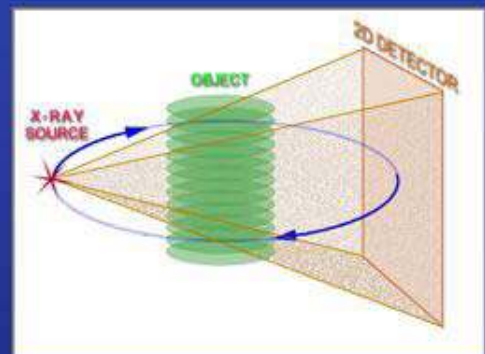
- a three-dimensional object is projected to on a planar film
- fracture or cavity structures
- sometimes small structures
- the visibility of internal structures (e.g. irregular cavity in a beadless cultured pearl) may vary strongly depending to the direction of the X-ray projection.



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X-ray micro tomography

- a three-dimensional object is slowly rotated and repeatedly exposed to projected to X-rays on a planar detector
- the projected scans are then reconstructed into a three dimensional model
- With specific software, we then can virtually scroll through the object



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X-ray micro tomography:

SkyScan1172 high-resolution micro-CT

- fully distortion corrected 11Mp X-ray camera,
- up to 8000x8000 pixels in every slice,
- down to 1 μm isotropic detail detectability,
- dynamically variable acquisition geometry for shortest scan at any magnification,
- computer cluster for 3D reconstruction,
- software for 2D / 3D image analysis,

Operating conditions (example):

Source Voltage (kV)= 100

Source Current (μA)= 100

Image Pixel Size (μm)= 5.93

Exposure (ms)= 590

Rotation Step (deg)=0.500

Scan duration=00:28:39

Reconstruction duration

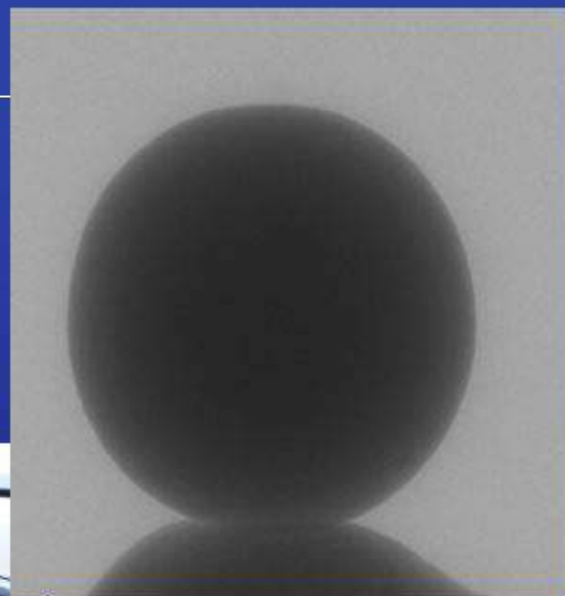
per slice (seconds)=0.886392



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X-ray micro tomography

Pearl mounted for X-ray micro CT analysis

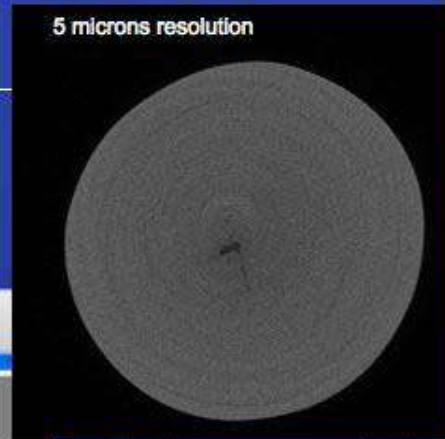
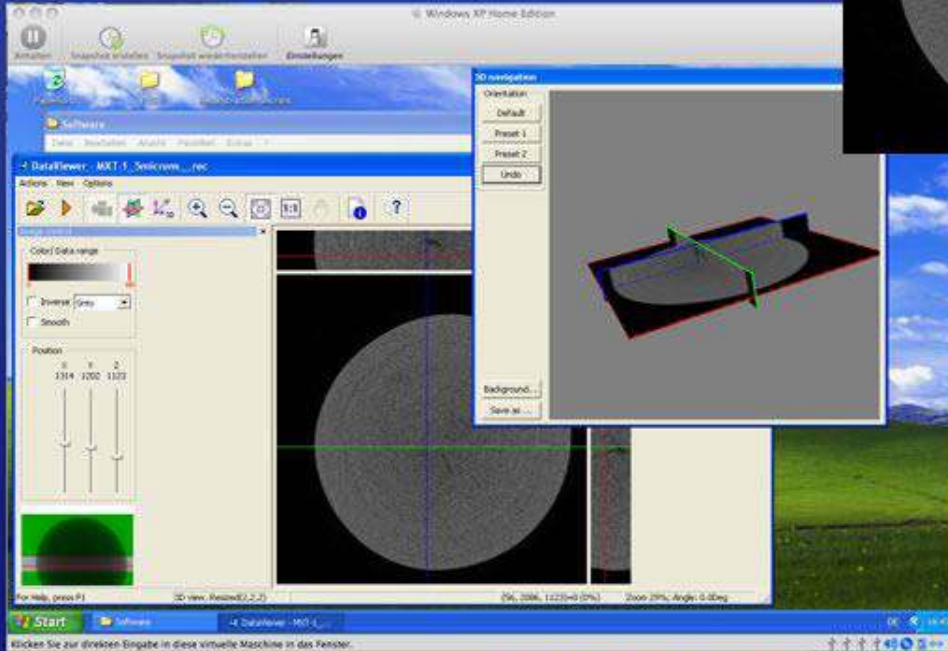


Projected X-ray scan of the pearl in one position

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X-ray micro tomography

Scrolling in 3 directions through the pearl



5 microns resolution

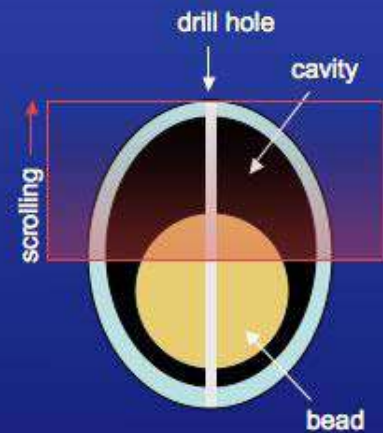
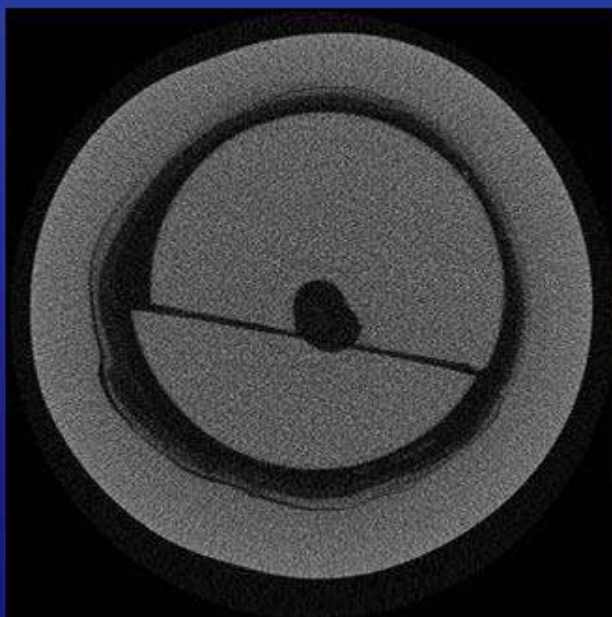
Reconstructed slice of a beadless cultured pearl

Three dimensional scrolling

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X-ray micro tomography

Beaded cultured pearl (*Pinctada maxima*)
Sample MXT 14b (5 microns resolution)

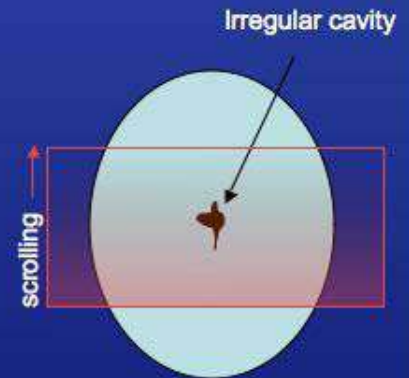
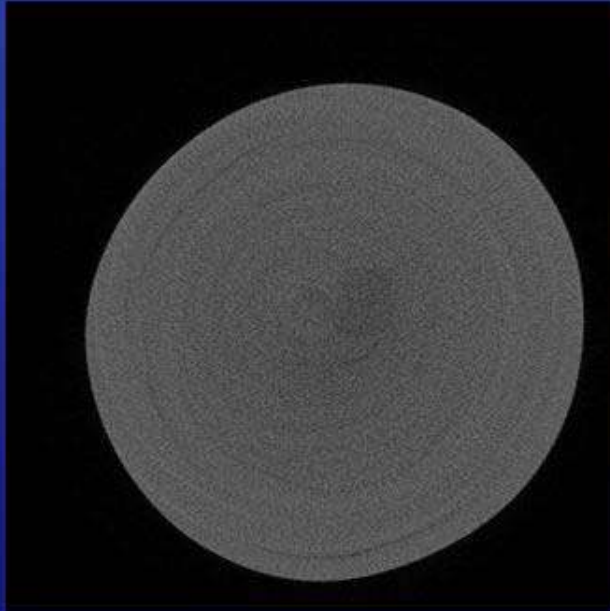


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X-ray micro tomography

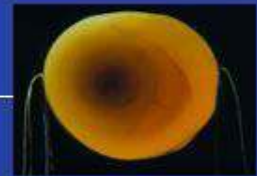


Beadless cultured pearl (*Pinctada maxima*)
Sample MXT 1 (5 microns resolution)

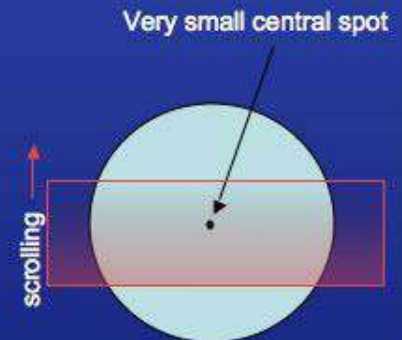
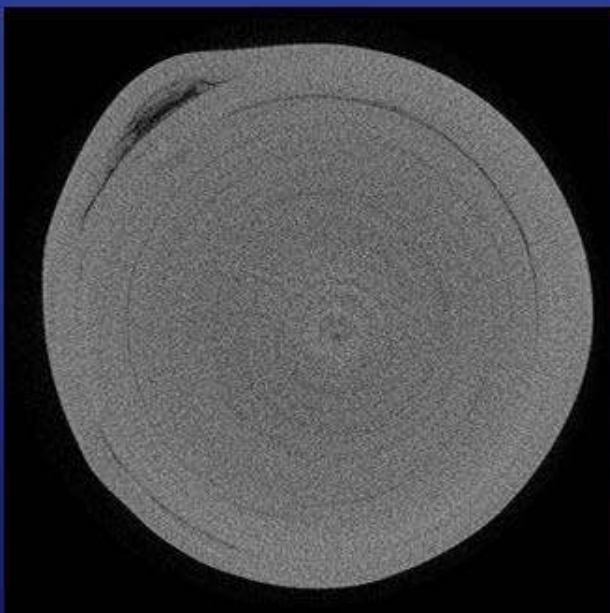


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X-ray micro tomography



Natural pearl (Mississippi freshwater mussel, *Unio*)
Sample MXT 3 (3 microns resolution)

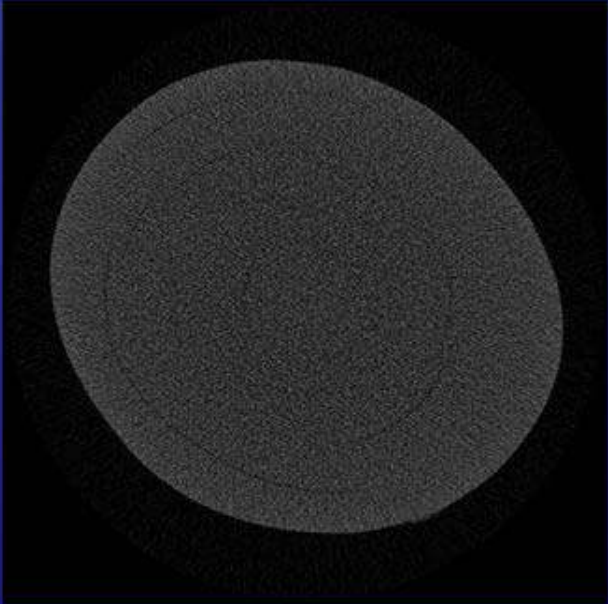


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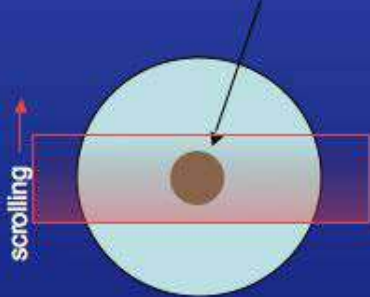
X-ray micro tomography



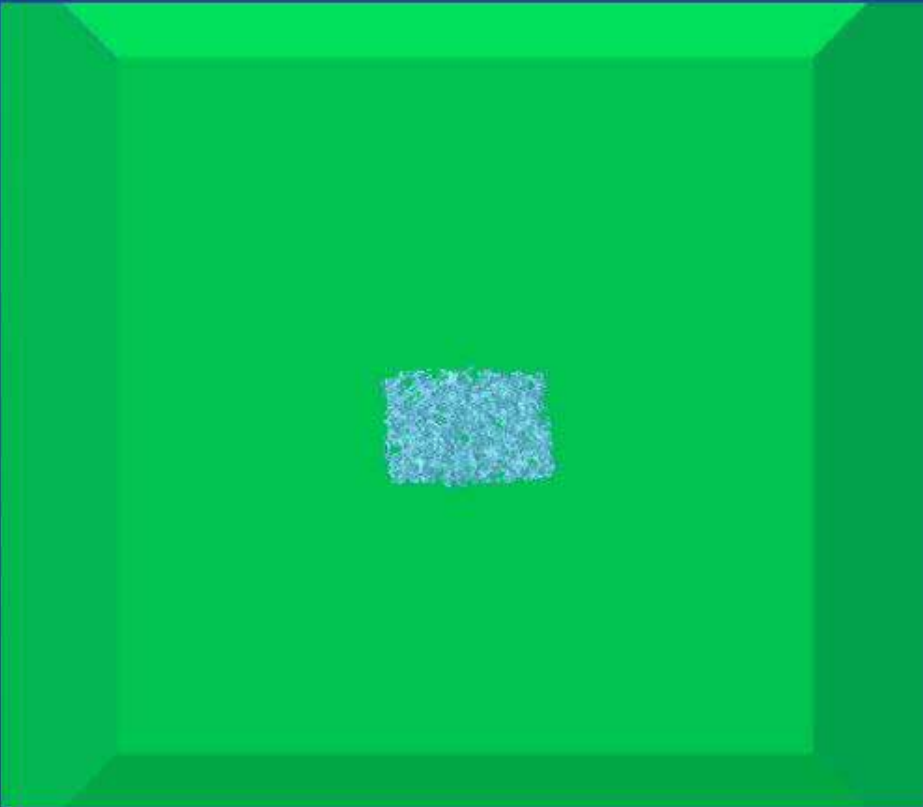
Natural pearl (Saltwater, *Pinctada radiata*)
Sample MXT 9 (6 microns resolution)



Core with radial calcite columns



X-ray micro tomography



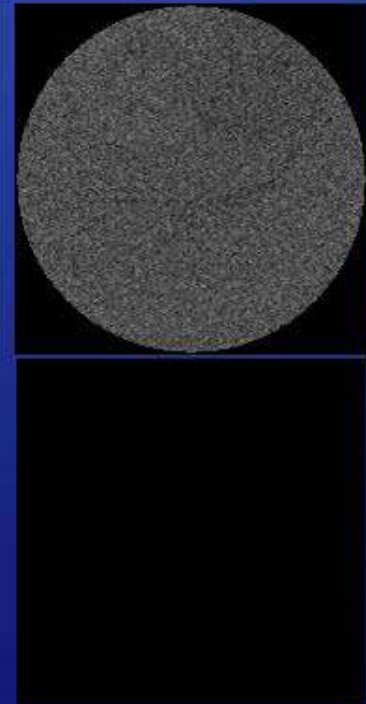
Foam:
Visualization of
as an X-ray
absorptivity
model

X-ray micro tomography



Beadless cultured pearl (Pinctada maxima)
Sample MXT 1 (5 microns resolution)

Modelling the irregular cavity and rotating the model



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X-ray micro tomography



Beadless cultured pearl (Pinctada maxima)
Sample MXT 1 (5 microns resolution)

Please note: The flat cylindrical shape is only reflecting the modelled part of the CT-reconstruction and has nothing to do with the pearl shape!



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Conclusions Part II: X-ray micro tomography

- X-ray micro tomography is a new and powerful non-destructive method for pearl testing.
- No sample preparation is required.
- We get a three-dimensional reconstruction of the pearl
- The analytical time per pearl is usually between 20 minutes and 2 hours
- Large data accumulation for reconstruction
- Only for pearls where traditional X-ray radiography has not enough sensitivity
- For single pearls
- Metal mounting produces artefacts

Natural pearls



Beadless cultured pearls



Since August 2009, the SSEF offers X-ray micro tomography as a service to our clients