



LMHC Technical Pearl Commission Meeting
Bahrain, 1-2 June 2010

X-ray micro computed tomography: an explanation of the procedures and benefits

Presentation by

Michael S. Krzemnicki

Swiss Gemmological Institute SSEF

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Pearls, pearls, pearls...



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Natural or cultured pearls ?

Large quantities of „new“ pearls arrive on the pearl market.



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Cultured pearls: the options

Limited combinations for CP's

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

from H.A. Hänni, 2008

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



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Saltwater beadless cultured pearls

- Gonad grown "Keshi" first generation

The bead is rejected just after implantation. The remaining inserted mantle tissue (epithelium) starts pearl formation in the gonads. Usually round to button and drop shapes.



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- Gonad grown "Keshi" second generation

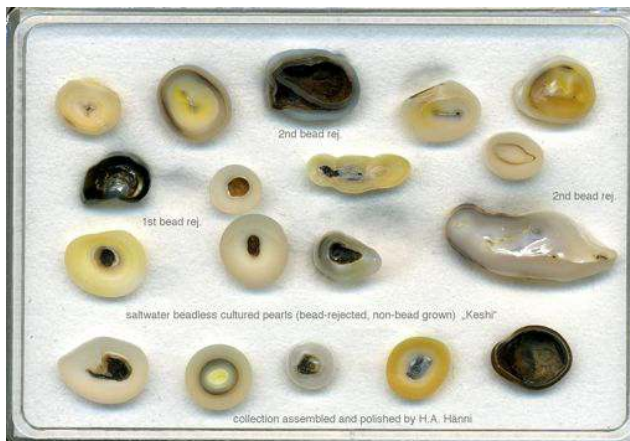
After the first harvest, a second bead was implanted in the existing pearl sac, but shortly after was rejected. The pearl sac collapses, but will continue to produce a pearl. Usually baroque shapes.



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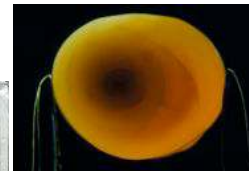


Cross sections



SW beadless cultured pearls

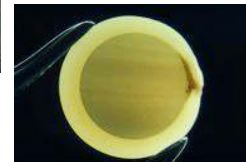
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Natural pearl



FW beadless cultured pearl

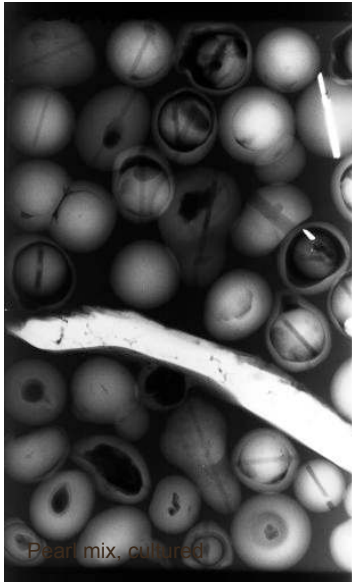


Beaded cultured pearl

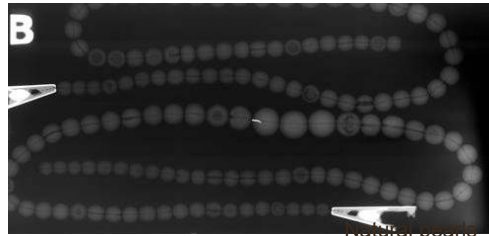
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X-ray radiography



Pearl mix, cultured



Natural pearls

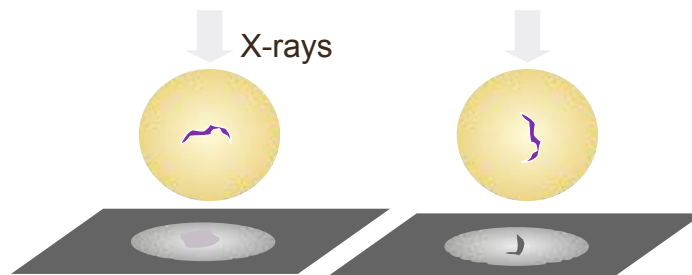


beadless cultured freshwater

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Problems when interpreting radiographies



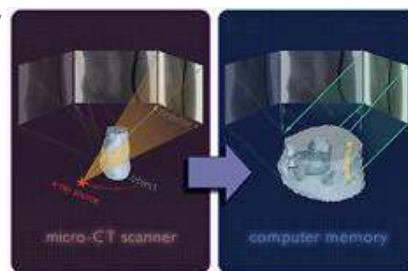
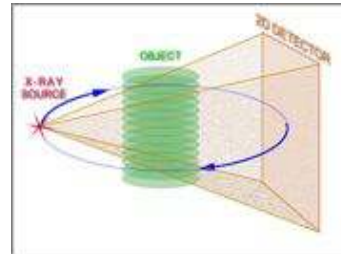
- a three-dimensional object is projected to on a planar film
- fracture or cavity structures
- sometimes small structures
- the visibility of internal structures (e.g. irregular cavity in a beadless cultured pearl) may vary strongly depending to the direction of the X-ray projection.

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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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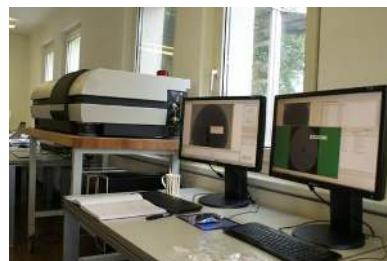
X-ray micro tomography (X-ray μ -CT)

SkyScan1172 high-resolution micro-CT

- fully distortion corrected 11Mp X-ray camera
- up to 8000x8000 pixels in every slice
- down to 1 μ m isotropic resolution
- 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) = 88
 Source current (μ A) = 100
 Image pixel size (μ m) = 3
 Exposure (ms) = 2356
 Rotation step (deg) = 0.30°
 Rotation (deg) = 360°
 Frame averaging = 2
 Scan duration = approx. 2 hrs
 Reconstruction duration = approx. 2hrs

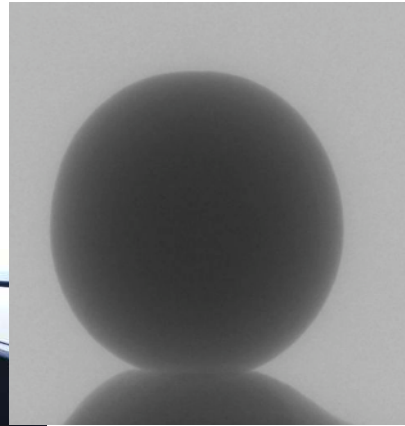


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X-ray micro tomography

Pearl mounted for X-ray micro CT analysis



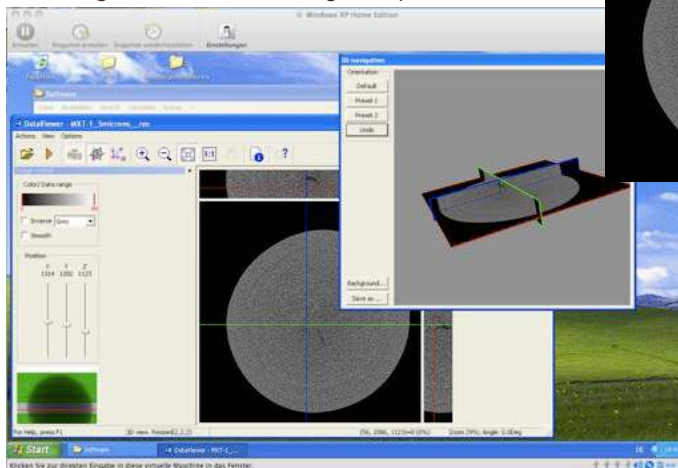
Projected X-ray scan of the pearl in one position

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X-ray micro tomography

Scrolling in 3 directions through the pearl




Reconstructed slice of a beadless cultured pearl

Three dimensional scrolling

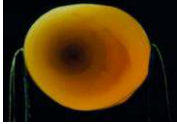
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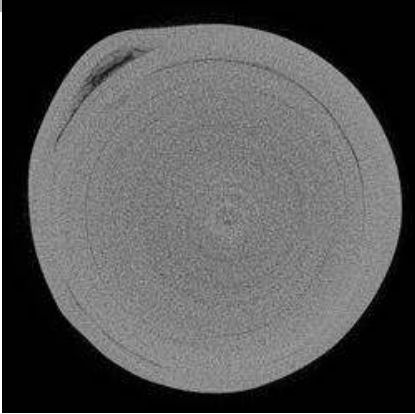


Natural pearl

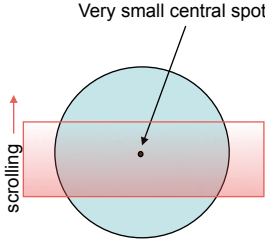


Natural pearl (Mississippi freshwater)
Sample mxt 3 (3 microns resolution)






Very small central spot




scrolling

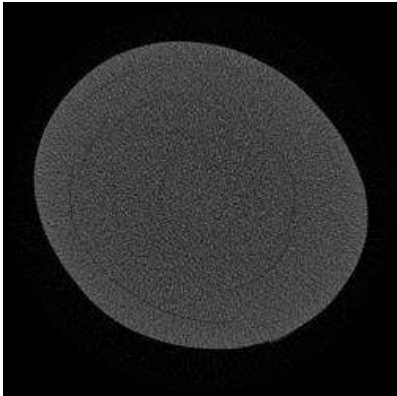
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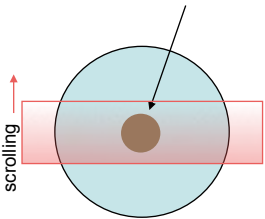
Natural pearl

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






Core with radial calcite columns





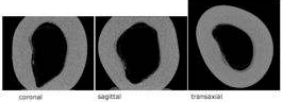
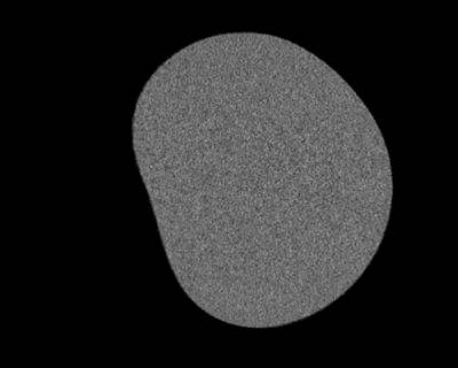
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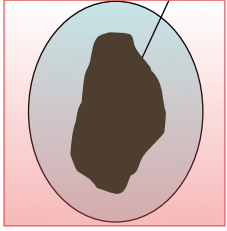


Cultured pearl (beadless)

Beadless cultured pearl (*P. maxima*)
Sample mxt 61-14

Large curved cavity





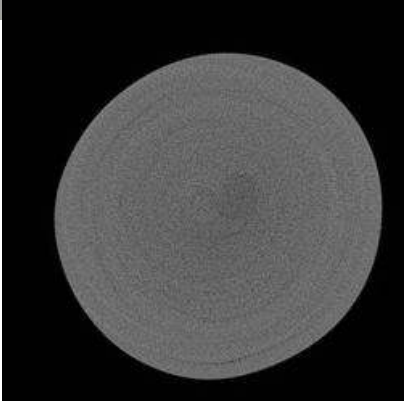
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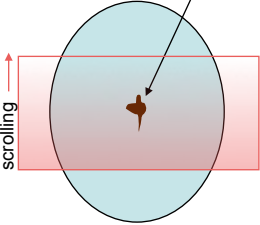
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Cultured pearl (beadless)

Beadless freshwater cultured pearl (China)
Sample mxt-1 (5 microns resolution)

Irregular cavity

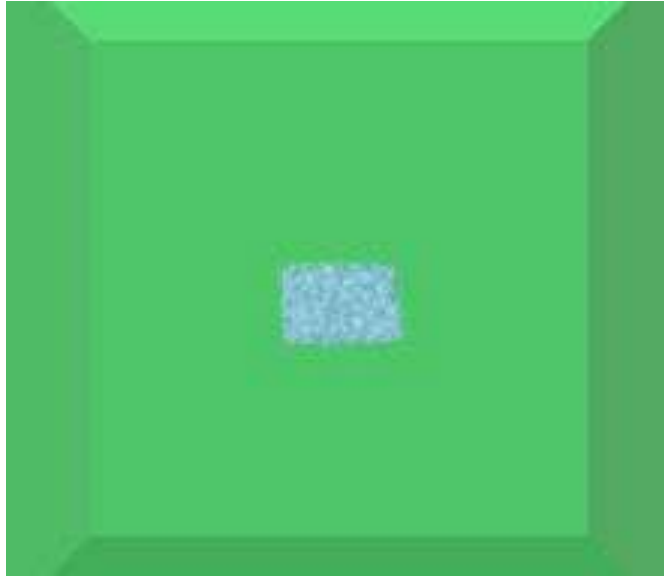


scrolling

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Micro X-ray tomography



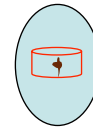
Foam:
Visualization of
as an X-ray
absorptivity
model

© Skyscan, Belgium

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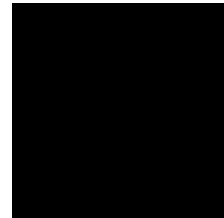
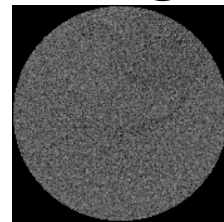
Beadless cultured pearl



Modelling the irregular cavity and rotating the model

Beadless freshwater cultured pearl (China)

Sample mxt-1 (5 microns resolution)



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X-ray micro tomography

Beadless freshwater cultured pearl (China) mxt 1



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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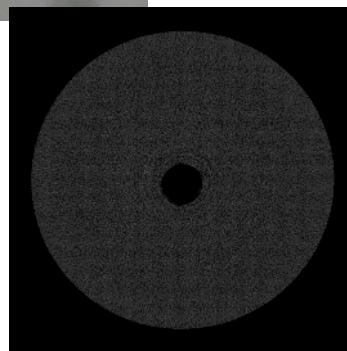
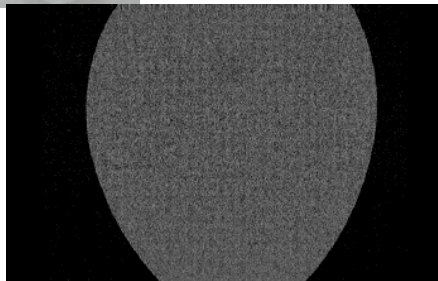
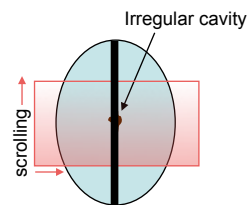
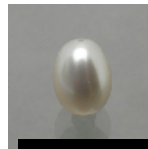


Beadless cultured pearl

Please note: Drilling may be a problem!



Two different pearls from *Pinctada maxima* !

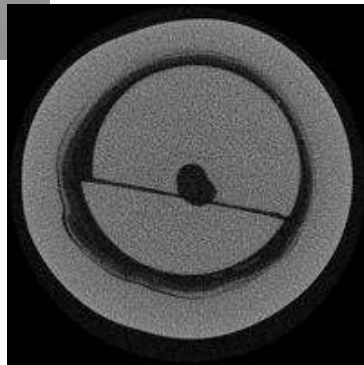


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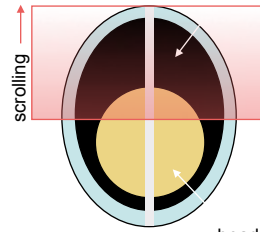
Cultured pearl (beaded)

Beaded cultured pearl (Pinctada maxima)
Sample mxt-14b (5 microns resolution)



drill hole

cavity



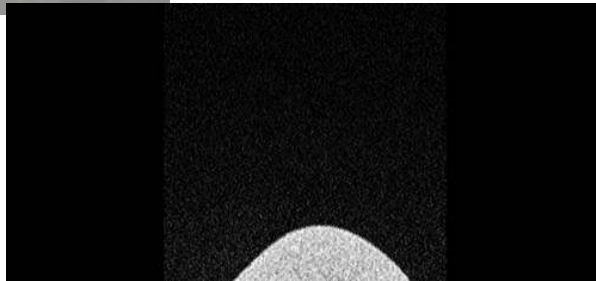
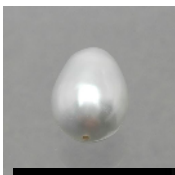
bead

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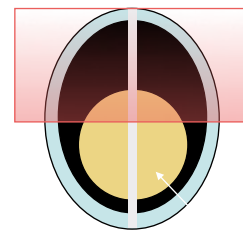


Cultured pearl (beaded)

Beaded cultured pearl (Pinctada maxima)
Sample mxt-14b (5 microns resolution)



scrolling



bead

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Special cases of cultured pearls:

Small additional beadless cultured pearls forming during pearl cultivation

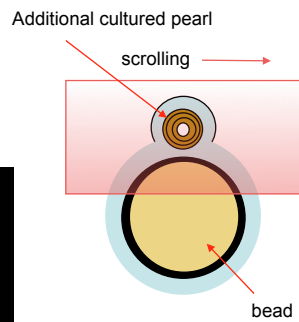
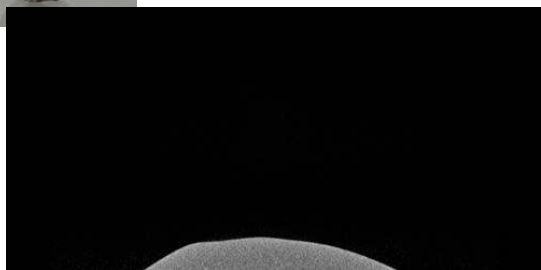


Photo © H.A. Hänni, SSEF 2010



Special cases of Cultured pearls

**Beaded cultured pearl (Pinctada maxima)
with attached small additional cultured pearl**
Sample mxt 21_1 (4 microns resolution)



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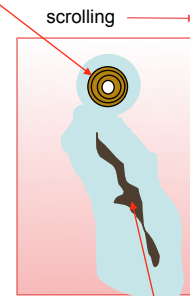
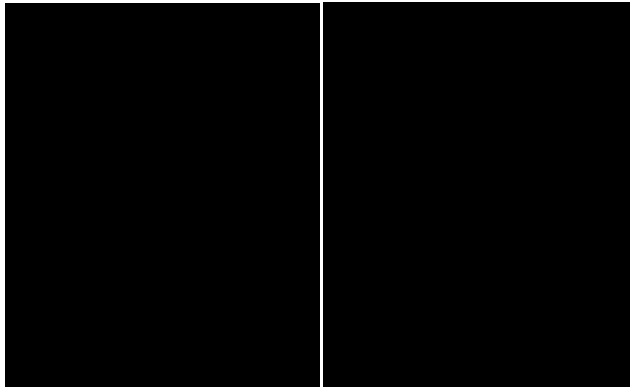


Special cases of Cultured pearls

**Beadless cultured pearl (Pinctada maxima)
with included small additional cultured pearl**
Sample mxt 21_2 (4 microns resolution)



Additional cultured pearl



Large cavity due to collapsed pearl sack after bead rejection

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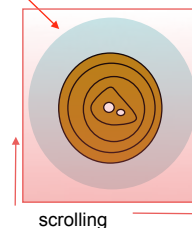
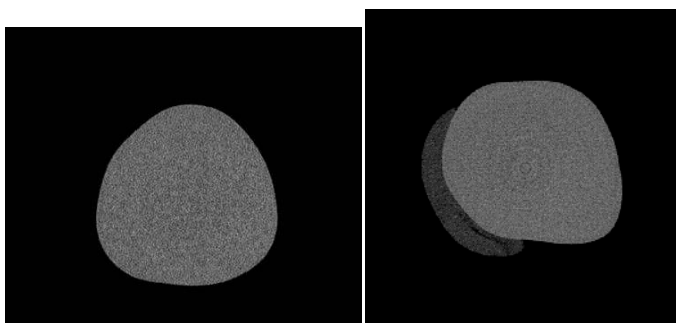


Special cases of Cultured pearls

**Beadless cultured pearl (Pinctada maxima)
grown during pearl cultivation**
Sample mxt 37_20 (2.3 microns resolution)



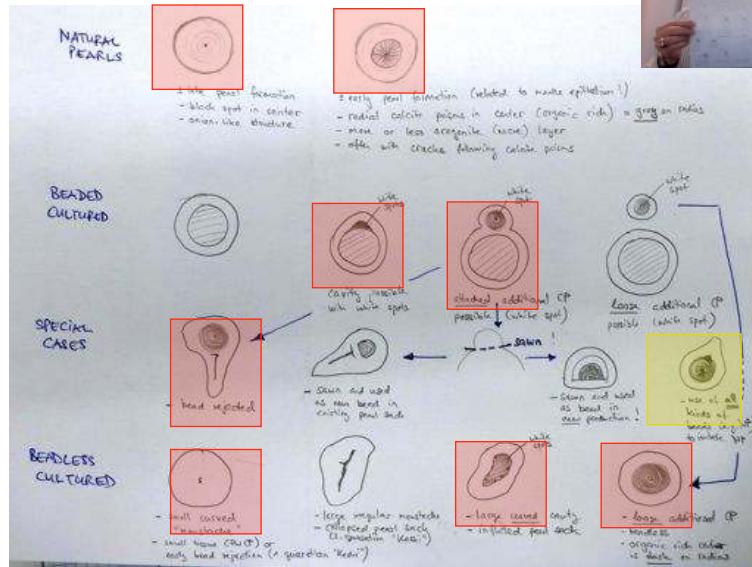
cultured pearl



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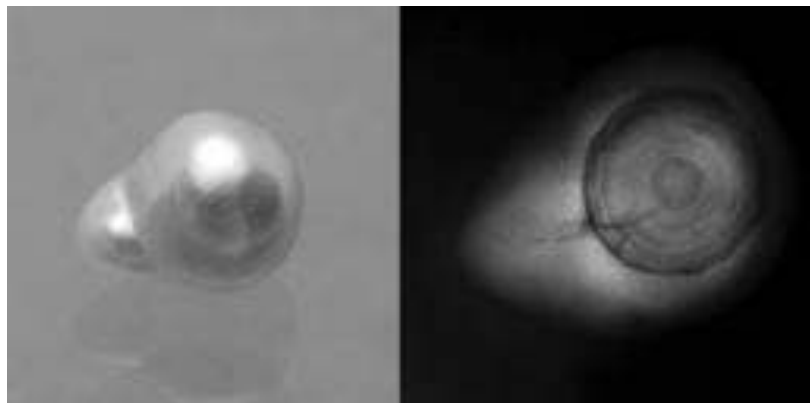
Pearl Structures



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"New" beaded Cultured Pearls: the next challenge...



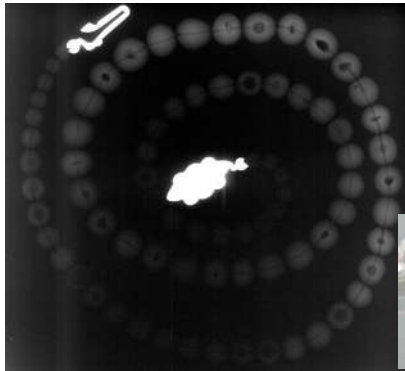
Beaded cultured pearl from *P. maxima* with a natural pearl used as „bead“

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Conclusions, part 1

- "New" pearls enter the market in large quantities
- Their quality is often outstanding compared to natural pearls
 - Their internal structures may be difficult and misleading
- We assume that part of these pearls are purposely selected (and/or produced) to enter the market as natural pearls!



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Conclusions, part 2

- X-ray micro tomography is a 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 (incl. reconstruction) is approx. 4 hours
 - Large data accumulation for reconstruction
- Only for single pearls where traditional X-ray radiography has not enough sensitivity
 - Metal mounting produces artefacts

See also: Krzemnicki M., Friess D., Chalus P., Hänni H. A., Karampelas, S. (2010). Micro X-ray Computed Tomography: Distinguishing natural from cultured. *G&G*, Vol. 37, No. 2 (submitted).

Karampelas S., J. Michel, M. Zheng-Cui, J.-O. Schwarz, F. Enzmann, E. Fritsch, L. Leu, Krzemnicki, M.S. (2010). X-ray Computed Micro-Tomography Applied to Pearls: Advantages and Limitations. *G&G*, Vol. 46, No. 2 (submitted).

Krzemnicki M., Friess D., Chalus P., Hajdas I., Hänni H. A. (2009). New developments in pearl analysis: X-ray micro-tomography and ¹⁴C radiocarbon age dating. *Proceedings of the 31st International Gemmological Conference, Arusha, Tanzania, 11-14 October*, pp. 29-31;

Krzemnicki, M.S. (2010a) "Keshi" cultured pearls are entering the natural pearl trade. *SSEF Press release (12 May 2010)* http://www.ssef.ch/en/news/news_pdf/newsletter_pearl_2010May.pdf

Krzemnicki, M.S. (2010b)...And what happens with the beaded cultured pearls? *SSEF Press release (20 May 2010)* http://www.ssef.ch/en/news/news_pdf/newsletter_pearl_2010May_add.pdf

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Thank you for your attention



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