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

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Natural or cultured pearls?

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

Cultured pearls: the options

Limited combinations for CP’s

<table>
<thead>
<tr>
<th>Oyster saltwater</th>
<th>Gonad grown</th>
<th>beaded</th>
<th>Akoya, Tahiti, South Sea, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Oyster saltwater</td>
<td>Gonad grown</td>
<td>beadless</td>
<td>“Keshi” bead rejected</td>
</tr>
<tr>
<td>Oyster saltwater</td>
<td>Mantle grown</td>
<td>beadless</td>
<td>New Type Baroque</td>
</tr>
<tr>
<td>Oyster saltwater</td>
<td>Mantle grown</td>
<td>beaded</td>
<td>not seen? (MoB)</td>
</tr>
<tr>
<td>*Muscle freshwater</td>
<td>Mantle grown</td>
<td>beadless</td>
<td>Biwa, Chinese freshwater, US</td>
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<td>China freshwater con, round</td>
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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 mantel tissue (epithelium) starts pearl formation in the gonads. Usually round to button and drop shapes.

- 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.

Cross sections

SW beadless cultured pearls

Natural pearl

FW beadless cultured pearl

Beaded cultured pearl

Photos © H.A. Hänni, SSEF

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X-ray radiography

- a three-dimensional object is projected to 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 on the direction of the X-ray projection.
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

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 μm 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 (μA) = 100
Image pixel size (μm) = 3
Exposure (ms) = 2356
Rotation step (deg) = 0.30°
Rotation (deg) = 360°
Frame averaging = 2
Scan duration = approx. 2 hrs
Reconstruction duration = approx. 2hrs
X-ray micro tomography

Pearl mounted for X-ray micro CT analysis

Projected X-ray scan of the pearl in one position

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

Natural pearl

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

Core with radial calcite columns
Cultured pearl (beadless)

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

Large curved cavity

Cultured pearl (beadless)

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

Irregular cavity
Micro X-ray tomography

Foam: Visualization of as an X-ray absorptivity model

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!

Beadless cultured pearl

Please note: Drilling may be a problem!

Two different pearls from Pinctada maxima!
Beaded cultured pearl (Pinctada maxima)
Sample mxt-14b (5 microns resolution)

Cultured pearl (beaded)

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

Cultured pearl (beaded)

Beaded cultured pearl (Pinctada maxima)
Sample mxt-14b (5 microns resolution)
Special cases of cultured pearls:

Small additional beadless cultured pearls forming during pearl cultivation

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

Additional cultured pearl
scrolling
bead
Special cases of Cultured pearls

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

Special cases of Cultured pearls

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

“New” beaded Cultured Pearls: the next challenge...

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

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:


Thank you for your attention