Appearance of new bead material in cultured pearls

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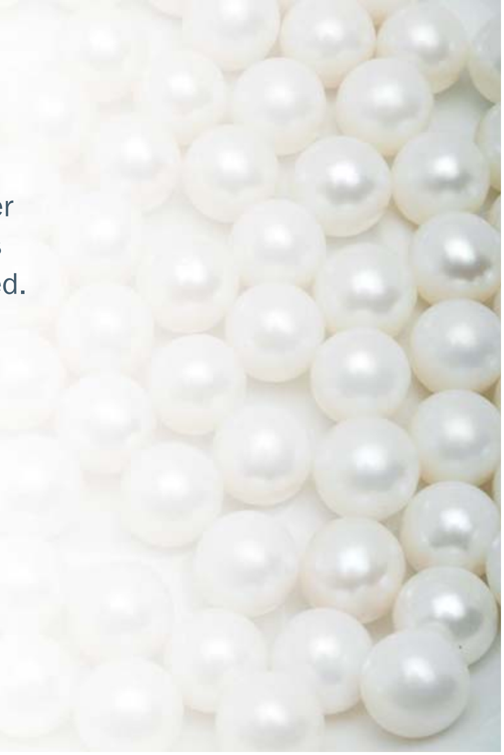
Abstract: A range of different materials has already been used as cores in beaded cultured pearls, and now two new alternative options, baroque shaped shell beads and Chinese freshwater cultured pearls, are being used. Experiments with beads of the latter, approximately 6.5 mm across, have been carried out with marine *Pinctada maxima* and *Pinctada margaritifera* oysters. After 13 months, nearly 200 pearls of each kind were harvested. Cross sections and further observations of resulting pearls are described. X-radiographs and X-ray microtomography are found to generally deliver clear evidence for identification. These pearls have been found to be very suitable for subsequent drilling. Natural pearls also have been used as nuclei for producing cultured pearls. The material used is either non-nacreous, brown or of an unattractive appearance. This new kind of cultured pearl is difficult to identify, because the radiographic structures of the natural cores are masking these cultured pearls.

Keywords: baroque-shaped beads, bead nucleus, Chinese freshwater cultured pearls, cultured pearls, South Sea cultured pearls, Tahiti cultured pearls, X-ray microtomography



Introduction

Techniques concerning production of cultured pearls have been described in a number of recent books and papers (Müller, 1997; Hänni, 2002; Strack, 2006; Southgate and Lucas, 2009). A number of options for pearling can be selected and combined to produce cultured pearls successfully, and these are summarized in *Table I*.

Traditionally, most beads for cultured pearls have been manufactured from shell material from the Mississippi area, USA (pigtoe, washboard, butterfly, three ridge, dove shell) but since production is in decline and prices are rising, alternative materials are being tested. Recently, an excellent paper comparing different bead materials used in cultured pearls was published by Superchi *et al.* (2008) in which the following materials are mentioned: banded freshwater mother-of-pearl, banded saltwater mother-of-pearl, Tridacna shell and Bironite. The use of lauegrams to detect the structures of beads has been practised for more than

Table I: Possible combinations of parameters to produce cultured pearls — the two major ways are given in blue.

Host and medium	Pearl location in the body	Presence of bead	Examples and comments
Oyster saltwater	gonad-grown	**yes**	**Akoya, Japan; Tahiti; South Sea**
		no	‘keshi’, bead rejected
	mantle-grown	no	new type, baroque shape
		yes	not yet encountered
Mussel freshwater	mantle-grown	**no**	**Biwa, Japan; China; USA**
		yes	Chinese, ‘coin bead’, round
	gonad-grown	no	not yet encountered
		yes	not yet encountered

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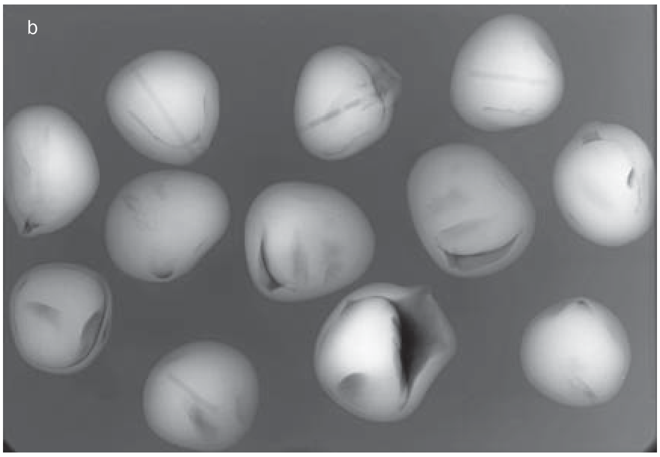


Figure 1: (a) Baroque-shaped South Sea cultured pearls containing irregularly-shaped shell beads. A number of such cultured pearls (largest dimension 17 mm) are seen in the left image. (b) A radiograph showing the irregular outlines of the bead material and some structures typical of growth near the hinge of the shell. Photo © H.A.Hänni and SSEF.

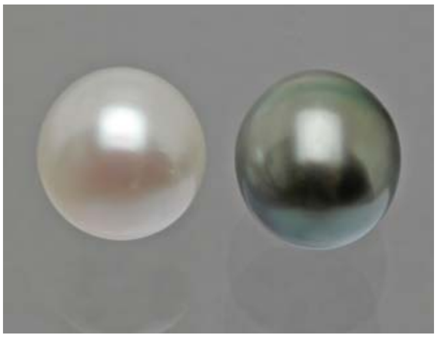


Figure 2: Gonad-grown cultured pearls of P. maxima *(left) and* P. margaritifera *(right) containing a CFCP as a nucleus bead. Diameter of the final product is approx. 9 mm. Photo © H.A.Hänni and SSEF.*

50 years, and in this context the structure of Tridacna shell and other non-nacreous shell has been discussed recently by Hanni (2004, 2009a). Besides Bironite, which consists of altered dolomitic marble, pressed barium sulphate beads in different colours have also been reported as cores in engraved dark *P. margaritifera* pearls (Hänni, 2009b). The latest substance used for producing baroque-shaped cultured pearls is irregularly-shaped shell material, used in *P. maxima (Figure 1)*.

Another new material, thus far unreported, is probably still being used on an experimental scale. This material is a freshwater cultured pearl and the aim of this article is to shed light on this alternative, as it is likely to be increasingly applied and encountered in future *(Figure 2)*.

Figure 3: A sample of Chinese cultured pearls (mantle-grown, beadless CFCPs) as used for beading of South Sea oysters P. maxima *and* P. margaritifera*. For a first beading of the oyster a diameter of approx. 6.5 mm is required. Photo © H.A. Hänni and SSEF.*

From a consumer point of view, the composition of the core in the bead-cultured pearl may not seem to be important as this material is not visible. However, to give the feeling of a pearl, it should have the heft of a pearl (this means that light materials such as plastic are not appropriate). From a production point of view, a suitable material should be accepted by the oyster or mussel and possess properties suitable for drilling. For about 100 years shell beads have satisfied these requirements (Muller, 1997). Nacre has the perfect heft as it is of the same material as natural pearls. But its layered structure sometimes can be a source of difficulties: when the drilling hole is at a low angle to the layers, a tendency to split along the layers can divert the drill off course. When the drill is parallel to the layers, the bead often breaks along the layers. The use of bead material made from the Tridacna shell is now defunct mainly because this bivalve is a protected species, but also because it has a fibrous structure that is difficult to drill due to the criss-cross array of fibres (Hanni, 2009b).

Such constraints are not encountered when concentrically structured nacre, such as that in a beadless cultured pearl, is used as bead material. Considering that Chinese freshwater cultured pearls

(CFCPs) of this kind are available in large quantities, close to round in shape, of white colour and at low prices, such material seems a perfect alternative to beads fashioned from shell. The only apparent disadvantage seems to be the lesser degree of roundness compared to the traditional manufactured beads. However, beadless CFCPs can easily be polished to spheres of standard sizes.

Figure 4: Cultured pearls containing the new CFCP beads from P. maxima *oysters (white) and* P. margaritifera *oysters (black) harvested after 13 months. The pearls are between 7.5 and 9 mm across. Photo © H.A.Hänni and SSEF.*

The experiment

Mantle-grown beadless CFCPs *(Figure 3)* were used to study the usability of the new bead material. A second objective was to examine the possibilities of identifying these alternatively beaded pearls in a gemmological laboratory. Because beadless CFCPs may exhibit concentric growth structures similar to those in natural pearls, it is important to find distinguishing features that one can use to differentiate these from natural pearls. Two hundred near-round to round and white to pale cream beadless CFCPs, unprocessed and with a diameter of approx. 6.5 mm, were delivered to each farm, one working with *P. maxima* and one with *P. margaritifera*. They went through the same preparatory steps in the pearl farms as conventional nacre beads. For comparison, a significant group of oysters was grafted and beaded with standard beads. After 13 months the pearls were harvested and the yield of CFCP beaded pearls was compared with the average of the normal production. The rejection rate was slightly lower for the CFCPs than for the traditional beads. This was the case for both *P. maxima* and *P. margaritifera*. The final cultured pearls from both farms had diameters between 7.5 and 9 mm. *Figure 4* shows a representative selection of the two lots produced from *P. maxima* and *P. margaritifera* oysters.

Twenty pearls from each production were randomly selected for tests. Some pearls were cut in half and polished so that the equatorial plane could be inspected under magnification *(Figure 5)*. Other samples were analysed non-destructively by X-ray techniques.

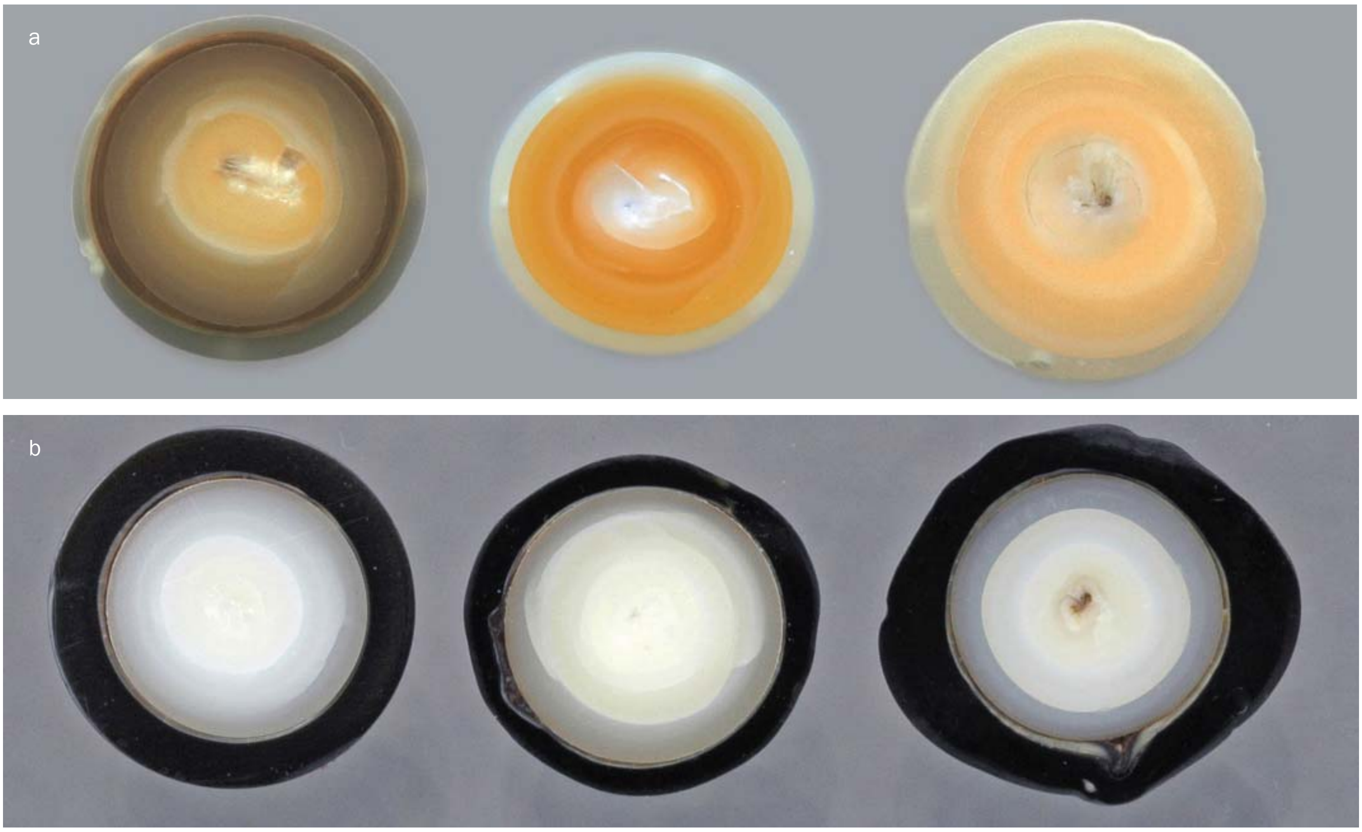
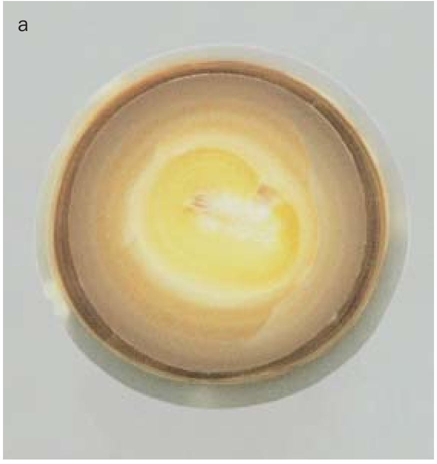


Figure 5: Cross sections through marine cultured pearls, containing a CFCP as a core. (a) Samples from the P. maxima *oyster, and (b) those from the* P. margaritifera *oyster. Photo © H.A.Hänni and SSEF.*



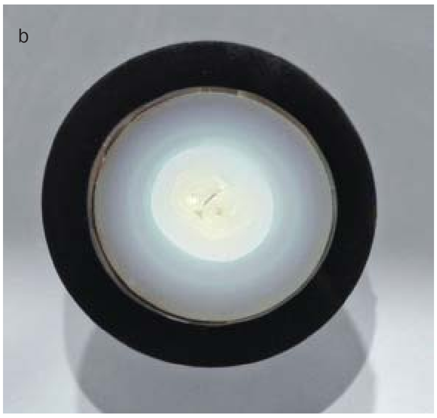


Figure 6: Cross-sections through P. maxima *and* P. margaritifera *cultured pearls, each containing a CFCP as a bead. The cavity, typically of complex shape, is visible in the centre and surrounded by a chalky area overgrown by nacre of the freshwater cultured pearl. These beads are coated by (a) white nacre in* P. maxima *and by (b) dark brown nacre in* P. margaritifera *oysters. Photo © H.A.Hänni and SSEF.*

Identification

The core

The most significant structure visible in the centre of the freshwater pearls used as beads is the central cavity. This complex cavity is bordered by the first precipitation in the young nascent pearl sac, and may be further surrounded by undulating hairlines and fine fissures between subsequent growth layers. In natural pearls, such fissures are concentric and bow-shaped. Drying fissures in natural pearls are usually across the pearl and cut through the concentric growth structure. The area immediately around the central cavity commonly consists of non-nacreous, pale yellow material that may include vaterite (Soldati *et al.*, 2008). This set of observations is typical for the CFCP bead material shown in *Figures 5* and *6*.

In comparison, natural pearls show an off-round central area consisting of a radiating array of pale brown columns, many of which have been identified as calcite (Lowenstam and Weiner, 1989; Baronnet *et al.*, 2008) (see *Figure 7*). This inner region contains more organic material and thus absorbs less X-ray energy, consequently appearing darker on the radiograph. It corresponds to the first formation of $CaCO_3$ deposited by the juvenile cells of the pearl sac. With increasing age, the cells change to producers of aragonite tablets and form a coat of nacre on the primary body. More on the formation of natural pearls is described by Hänni (2002) and Bari and Lam (2009).

The overgrowth

An average nacre thickness of 0.5 – 1.8 mm was measured on the beads. This overgrowth is less than usual because the growth time was only 13 months. Usually the overgrowth on the experimental beads sits very tightly on the CFCP. In some the innermost deposition on the bead is of columnar $CaCO_3$; this forms before the pearl sac begins to precipitate $CaCO_3$ as aragonite tablets, i.e. nacre; in others, aragonite is deposited directly on the bead. Most white South Sea pearls are close to round, but it is not uncommon for the black Tahiti pearls to have circle and drop shapes; this shape variation is not related to the material of the beads.

Identification by X-ray shadow pictures on film or digital image is usually a straightforward procedure for beaded pearls. The presence of a central cavity in the shape of a so-called 'moustache' structure, which is typical of beadless cultured pearls including CFCPs, would be a clear indicator of a bead's character (see ***Figure 8***). In situations where such structures are not clearly shown at the first attempt, a rotation of the pearl can result in better exposure of the cavity. Any flat

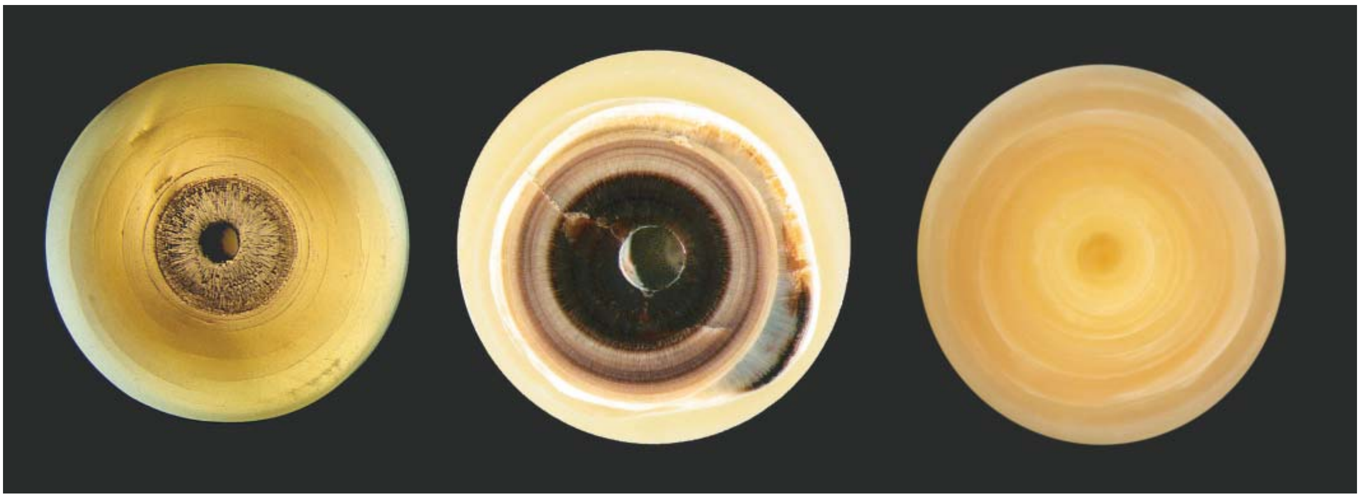


Figure 7: Sections through three natural pearls. The centres show radiating prismatic $CaCO_3$, containing brown organic material. This core is overgrown with nacre. Some natural pearls, such as the sample on the right, may lack the columnar brown part. Photo © H.A.Hänni and SSEF.

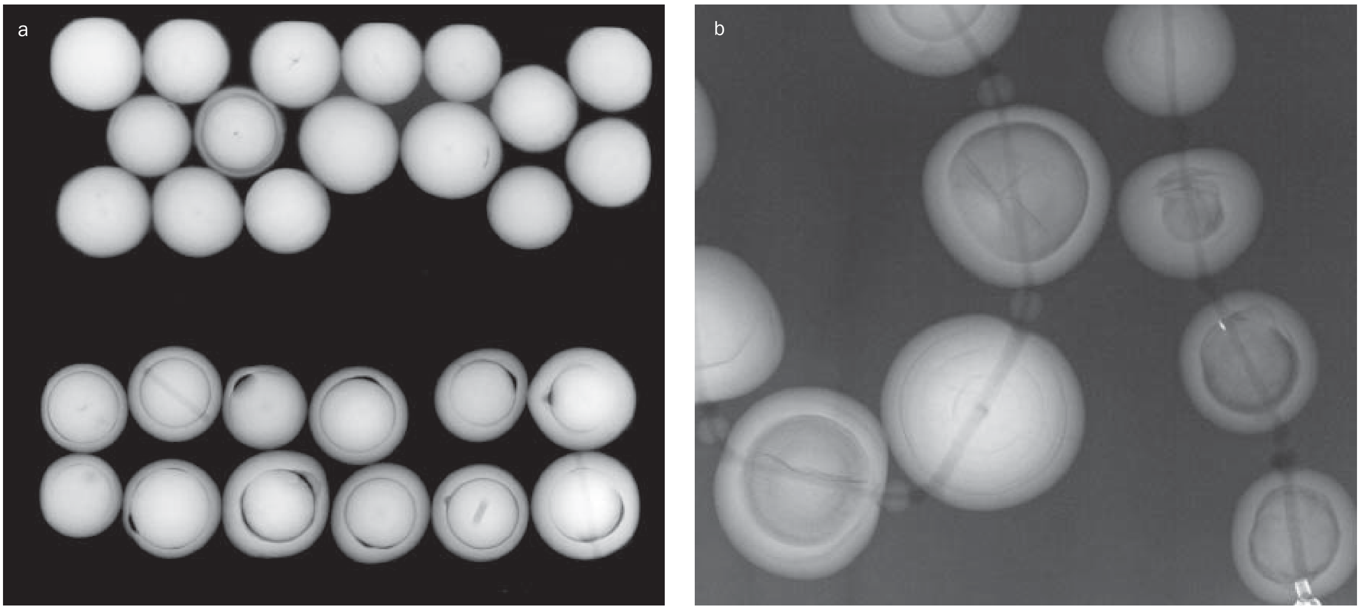


Figure 8: (a) Traditional X-radiographs, the central parts of which are examined under magnification, to look for the 'moustache' structure. The upper group are white South Sea beaded cultured pearls and the lower group consist of black South Sea cultured pearls. The straight line shadows indicate drill holes in three pearls of the lower group, and most pearls in this group show a clear gap between bead and nacre overgrowth.
(b) Radiographs of natural pearls with off-round outlines, most showing a conchiolin-rich central area and irregular wavy lines indicating fissures caused by drying. Only one pearl lacks a conchiolin-rich centre and that is the white one in the lower centre of the picture. Photo © H.A.Hänni and SSEF.

structure appears much more clearly when it is parallel to the incoming rays, thereby producing a sharp line. When the cavity is rather thin and flat and perpendicular to the incoming rays, it may be difficult to detect. It thus becomes clear that dynamic investigation such as real time radiography (Sturman, 2009) with the opportunity to rotate specimens is preferable for obtaining reliable results more quickly. In addition to the comments made above, it is worth noting that since freshwater pearls contain manganese, they are more absorbent of X-rays and thus appear brighter on the radiograph.

The latest development in pearl investigation by X-ray technology is X-ray microtomography (Strack, 2006, 2007; Wehrmeister *et al.*; 2008, Anon, 2009; Krzemnicki *et al.*, 2009). By three dimensionally recording the radio density of a pearl in very small increments, a complete representation of the interior of a pearl is obtained. Sections in all directions can be looked at and ultra-fine structures in pearls can be visualized. With a set of mapped tomography data it is possible to view a scan through a pearl, and find the features necessary for identification. As this instrument remains

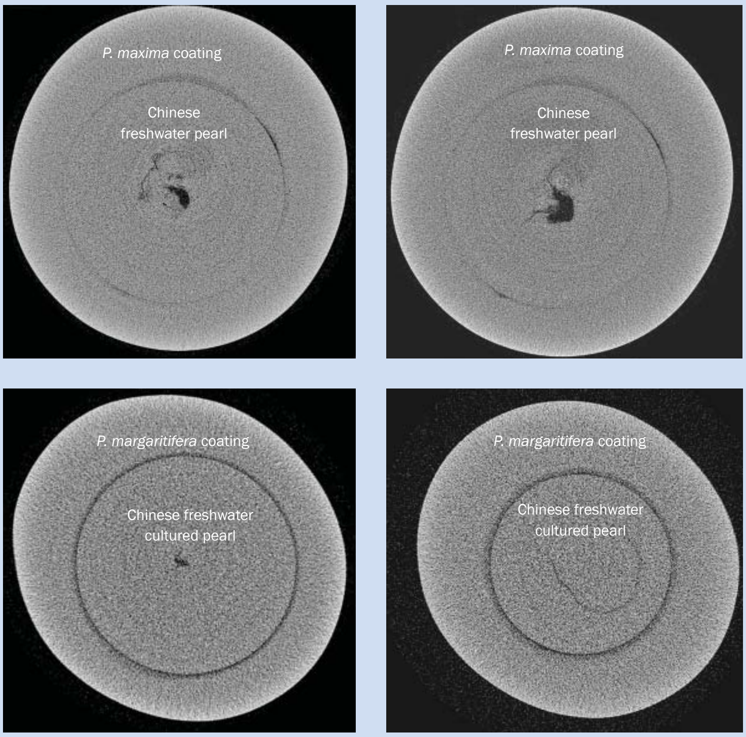


Figure 9: X-ray microtomographic sections of beaded cultured pearls. The beads consist of beadless CFCPs, showing central cavities and some irregular hairline fissures. The upper images are virtual cross-sections of a pearl from a white South Sea oyster P. maxima *taken at different levels and showing close contact of the bead and the nacre overgrowth. The lower images are virtual cross-sections of a pearl from a dark South Sea oyster* P. margaritifera. *This one has a prominent gap between core and overgrowth. Image © S. Friess, Gloor Instruments.*

expensive, it is currently used in rather exceptional situations where conventional radiography is not conclusive. To obtain tomographic data for the new type of beaded cultured pearls, two samples were recorded at Gloor Instruments (Uster) using a SkyScan microtomograph. Two cultured pearls with CFCP beads are shown in *Figure 9*. The CFCPs show central cavities and some irregular hairline fissures and again the boundary between the bead and the nacre coating is much more pronounced in the *P. margaritifera* oyster (lower) than in the *P. maxima* oyster. However, these are preliminary results and subject to change when more examples are available.

Larger CFCPs (from 9 mm upwards) can serve as second beads, after the first cultured pearl has been harvested, when the pearl sac is recharged.

Discussion

The purpose of creating a beaded cultured pearl is to produce an object of given shape and size coated with nacre to appear like a natural pearl. In the classical Japanese akoya cultured pearls the excellent nacre of the *Pinctada maxima* oyster can cover the nucleus with less than a millimetre of deposition, but this is only a thin paintwork to hide the nature of the core. Cultured pearls of better qualities usually display more than a millimetre of overgrowth. With this the body grows in size and optical attractiveness.

Seeing that the use of beadless freshwater cultured pearls in saltwater oysters causes no apparent problems, the next step seems logical. Unattractive natural pearls could be provided with a more beautiful surface if they stayed for a while in a farm-oyster. In order to recognize and understand the features of possible future varieties of cultured pearls, one author (HAH) has been experimenting with natural pearls as bead material. This turns out to be very relevant as recently cultured pearls with natural pearls as beads have reached the pearl trade, see reports on the internet (Gemlab, 2010; SSEF, 2010). This situation has similarities with that of blue sapphire in the 1980s. At that time, greyish unattractive rough corundum (geuda) could be transformed into a transparent blue gemstone rivalling natural sapphire. Although the pearl and sapphire technologies are different, the general aim is the same — that of transforming unattractive natural objects into good-looking and desirable jewels.

Conclusions

Market pressure for large, fancy-shaped cultured pearls has stimulated the use of baroque shaped pieces of shell to use as nuclei for South Sea cultured pearls. Using radiographs, these pearls are easily identified as cultured. Now a new bead material, which can be used for the first beading where a pearl sac has to be formed from a tissue graft around a spherical hard nucleus, has been found for cultured pearls: CFCPs are a viable replacement for beads cut from shell material. Experiments have shown that the new bead material gives good results in white South Sea oysters *P. maxima*, and dark South Sea oysters *P. margaritifera*. In a gemmological laboratory the CFCP beads can be identified using conventional radiography or X-ray microtomography. In each method the typical characteristics, a central complex cavity 'moustache' and undulating dark lines, can be detected. The comparative costs of these CFCP beads and conventional shell beads will probably determine whether this new bead material will be preferred in the trade. Since the structure of a CFCP bead is concentric, it is suitable for most drilling purposes as any variation in hardness due to growth factors will tend to be perpendicular to the drill direction.

Use of natural pearls of low quality (nacreous or non-nacreous) as beads is pushing the gemmological laboratories to develop new testing methods, and adapt terminology. Indeed, in some instances the authenticity of a pearl cannot conclusively be decided; structures such as those shown in *Figure 6* are no longer proof of authenticity. Some non-nacreous pebbles of columnar calcite have been called 'unripe pearls' by one author (HAH). Such 'pearls' have been harvested before deposition of a nacreous layer by the pearl sac, the latter still being at a juvenile stage before developing the capacity to form aragonite (Hänni, 2002). It seems that the lack of a nacreous layer on a pearl can now be remedied by a visit to a domestic oyster, but then of course, the status of the pearl changes from natural to cultured.

Acknowledgements

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