Fake Pearls Made from *Tridacna gigas* Shells

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Five non-nacreous 'pearls' that allegedly came from *Tridacna gigas* (giant clams) were studied for this report. Our observations revealed that none of them were pearls, but instead they had been manufactured from *Tridacna* clam shell. The identification of such imitations is in most cases straightforward, and is mainly based on their characteristic layered structure observed in reflected light and with transmitted fibre-optic illumination. Our results are compared with recent reports of other such fake pearls that are often wrongly described as being genuine natural pearls.

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Introduction

Pearls inspire the imagination of mankind, as they have represented status, good fortune and wealth since historic times. Therefore, it is no surprise that, even today, exceptionally large pearls attract much interest among the public (even though they are not nacreous). Occasionally reports on such objects appear in popular news media, in which they are commonly and correctly described as formations from the *Tridacna* clam (e.g. *Tridacna gigas*). A single account from a local newspaper may be multiplied by press agencies, so that a story based on just one pearl is then covered in many newspapers and websites, thus making its way into worldwide headlines.

Due to such recent media coverage, the authors' laboratory is being confronted with numerous requests to analyse similar non-nacreous 'giant pearls'. This article documents the results of our testing on five such items at SSEF (Figure 1), all of which proved to be fake pearls that had been cut and polished from *Tridacna* clam shell.

Tridacna Clams and Their Pearls

Tridacna clams (Tridacninae subfamily) are among the largest living bivalve molluscs, with a shell diameter up to 110 cm (Sarasin, 1904; Rosewater, 1965). Inhabiting shallow coastal waters of the Indo-Pacific region (Rosewater, 1965), these species are nowadays among the most endangered clams and are protected by the Convention on International Trade in Endangered Species (CITES, 2016). Their white shell is massive and thick, and shows a characteristic and attractive wave-like cross-section. As such, the shell has been used for adornment in native cultures and historically as fonts (vessels containing holy water) in Catholic churches throughout Europe (e.g. Saint Sulprice in Paris, France: Figuier, 1868, p. 148; Kunz and Stevenson, 1908, p. 76).

The presence of symbiotic single-celled dinoflagellate algae (zooxanthellae) in the mantle tissue of *Tridacna* clams not only results in a colourful appearance of the living animal, but also is regarded as the reason for the growth of the

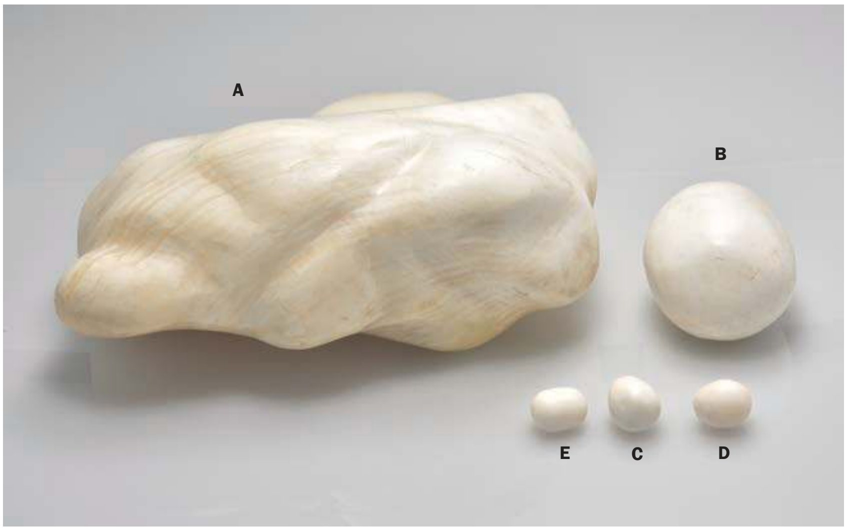

Figure 1: These five fake pearls (samples A–E), all cut from the shell of giant clams, were studied for this report. The largest item is 27 cm in diameter and weighs 6.8 kg. Photo by V. Lanzafame, © SSEF.

massive calcium carbonate shells of these species (Dame, 2011).

Pearls, blister pearls (i.e. those attached to the inner wall of a shell) and blisters (i.e. internal protuberances of the shell caused by the intrusion of foreign bodies between the mantle and the shell) from *Tridacna* clams are known in the trade (e.g. Kunz and Stevenson, 1908; Bari and Lam, 2010; Singbamroong et al., 2015; see also www.pearl-guide.com/forum/content.php?76), but due to their often rather dull whitish appearance and baroque shape (e.g. Figure 2) they have not gained much interest so far, except among a few pearl collectors. The shell material of *Tridacna* clams consists of regularly and densely interwoven aragonite fibres, similar to *Strombus gigas* (queen conch: Osuna-Mascaró et al., 2014) and many other gastropods. This partially results in fine 'flame structures' when viewed in reflected light (Hänni, 2010). As a consequence, both natural pearls and polished shell pieces from *Tridacna* clams often show such flame structures on their surface. However, not all non-nacreous white natural pearls claimed to be from *Tridacna* clams (Lai, 2014; Singbamroong et al., 2015) necessarily originate from the Tridacninae subfamily. They may also be the beautiful products of other mollusc species—misnamed as *Tridacna* clam pearls, since there is currently no method for the species identification of such non-nacreous white pearls. This is very much in contrast to nacreous pearls, which currently can be separated genetically (Meyer et al., 2013), and also in some cases by UV-Vis-NIR reflectance and Raman spectroscopy.

Samples and Methods

For this study, we investigated five samples (specimens A–E, Figure 1) submitted to SSEF by one client who reported them to be *Tridacna* pearls originating from Palawan, an island in the eastern Philippines. The samples ranged in weight from 6.8 kg (A) to 18.4 g (E) and in maximum length from approximately 27 to 2.6 cm. The large size and weight of some of the samples precluded our normal pearl testing procedure, so we based our conclusions mostly on careful observation of surface textures with the unaided eye and the microscope (Eickhorst LED Leica Gemmaster). In addition, for sample E we performed Raman spectroscopy with a Renishaw InVia microscope and chemical analysis by energy-dispersive X-ray fluorescence (EDXRF) spectroscopy using a Thermo

*Figure 2: A large hollow natural blister is shown attached to the inside of a giant clam shell (*Tridacna gigas*). A loupe is shown for scale; the shell measures approximately 26 cm wide. Photo by Luc Phan, © SSEF.*

Scientific Quant'X instrument. Also, X-radiography was performed on the three smaller samples (C, D and E) using a Yxlon Cougar digital X-ray setup.

Visual and Microscopic Observations

We divided the study specimens into two categories according to their shape (again, see Figure 1). The largest sample (A) displayed a baroque shape, visually somewhat reminiscent of the wave-like form of *Tridacna* shell. The remaining specimens (B–E) were oval to slightly baroque, and thus were more typical of the shapes exhibited by pearls.

Viewed with reflected light, all five specimens showed distinct curved, layered structures across their entire surfaces. These structures had no direct correlation to the shapes of the specimens, but were consistent with the undulating layered structures of *Tridacna* clam shell. Sample B exhibited a complex curved and folded structure (Figure 3) that appeared to represent the hinge of the clam; this area possesses the thickest accumulation of calcium carbonate in *Tridacna* shells.

Close examination of all the samples further revealed distinct polish marks in random orientations (e.g. Figure 4), as would be expected from items worked into a roundish shape. The low-quality polish, suggesting a rushed 'production' of these items, contrasts with the highly polished specimens of manufactured shell material that have been previously examined at SSEF (e.g. Krzemnicki, 2006).

Figure 3: The surface of specimen B (8.6 cm long), cut and polished from Tridacna *shell, exhibits distinct curved lines representing seasonal growth layers. Photo by V. Lanzafame, © SSEF.*

Figure 4: Distinct polish marks on the surface of fake pearl sample C result in a low-quality polish. Photo by M. S. Krzemnicki, © SSEF; image width 10 mm.

Using a strong transmitted fibre-optic light source, it was possible to investigate the internal structure of the five study samples. All showed distinct and sharply defined internal layering (Figure 5), representing the seasonal calcium carbonate precipitation layers of the shell in *Tridacna* species. Such features are not commonly observed in pearls, which form by precipitation of concentric spherical layers within the pearl sac of a mollusc.

Although surface- or subsurface-related striae in genuine *Tridacna* pearls might occasionally produce a somewhat layered appearance with transmitted fibre-optic illumination (Lai, 2014),

Figure 5: Viewed with transmitted fibre-optic illumination, this close-up of specimen D (22.5 g) reveals the layered structure of the Tridacna *shell from which it was cut. Photo by M. S. Krzemnicki, © SSEF; image width 11 mm.*

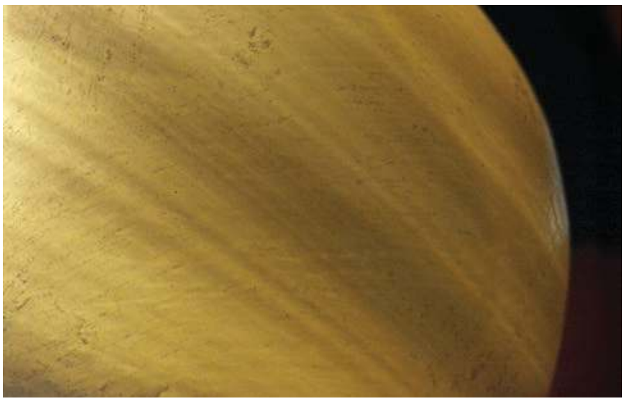

Figure 6: A reported 'giant pearl' weighing 34 kg provides a recent example of a fake pearl that made its way into worldwide headlines via the Associated Press in August 2016. The shape, layered structure and poor surface polish provide strong combined evidence that this object has been manufactured from Tridacna *shell.*

the present samples did not show any such striae, but rather only a badly polished surface.

The complex and sharp banding exhibited by the present samples (e.g. Figures 3 and 5) is also very different from the weak circling bands occasionally observed in non-nacreous white pearls from various molluscs, such as *Spondylus* spp. (Ho and Zhou, 2015) and *Fusinus* spp. (Bari and Lam, 2010, p. 75). These circles (seen as parallel bands when viewed from the side) are due to growth heterogeneities aligned by the rotation of the pearl during its formation (Gueguen et al., 2015). Typically these bands are rather broad and diffuse, and are visible either as a sub-surface effect when illuminated with a strong light source or at the surface (i.e. in nacreous pearls), where they may negatively affect the quality of a pearl. Such pearls commonly show a distinct rotational shape (button to long-prismatic oval) and occasionally reveal distinct flame structures radially emanating from rotational axis points at their top and bottom.

Viewed with the microscope, some of the five study samples revealed weak and fine flame structures perpendicular to the layering, similar to those described by Hänni (2010), but no flame structures were seen radially emanating from a distinct (rotational axis) point.

Based on these observations, we concluded that all five study specimens were fake pearls that had been cut and polished from the massive shells of *Tridacna* clams. Such imitations—typically of rather small size—have been manufactured since historic times (mostly then from *Unio* freshwater mussel shells) and have been described in detail by Kunz and Stevenson (1908, pp. 361, 494 and 497).

Advanced Testing

Raman spectroscopy of sample E revealed that it consisted of aragonite, as expected for *Tridacna* clams (Hänni, 2010). EDXRF analysis of this sample showed the expected major amounts of Ca along with traces of Sr (0.25 wt.% $SrCO_3$), but with Mn below the detection limit, clearly supporting a formation of the biogenic calcium carbonate in marine waters. X-radiography of samples C, D and E revealed no discernible internal structures such as layers or internal cavities in any of these specimens. This result is very common for non-nacreous pearls or shells (or beads made from such shells) that consist completely of densely interwoven aragonite fibres.

Further Cases of Fake Pearls from *Tridacna* Clams

From time to time, the authors' laboratory is asked to analyse 'giant pearls', and these objects are often accompanied by dubious identification and appraisal documents. Since the international media highlighted such a 'giant pearl' in August 2016 (e.g. Figure 6), the number of such requests has increased steadily. Although the authors have not personally studied the 'giant pearls' claimed to originate from *Tridacna* clams that have recently appeared in the media, we are convinced that most—if not all—of them are in fact fakes that were manufactured from the shell of *Tridacna* clams. This opinion is based on their apparent similarity in shape, layered structure and surface polish to the study samples we described above.

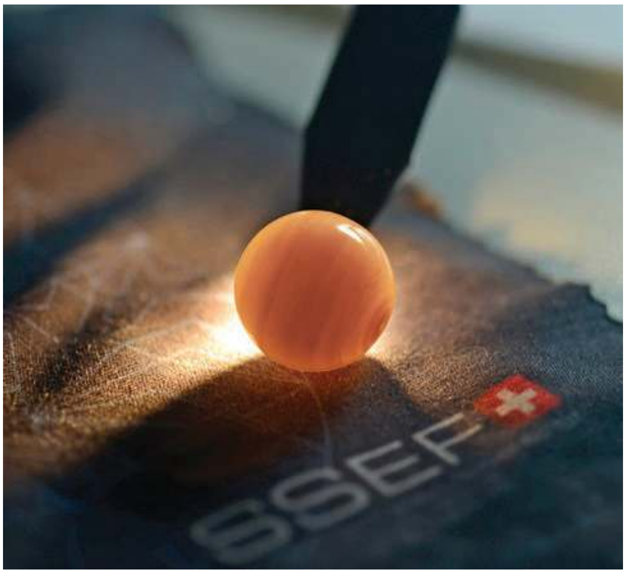

Figure 7: This 'pearl' (18.6 mm in diameter) is actually a bead cut from Tridacna *shell. The shell layers are distinctly visible when illuminated with fibre-optic lighting. Photo by M. S. Krzemnicki, © SSEF.*

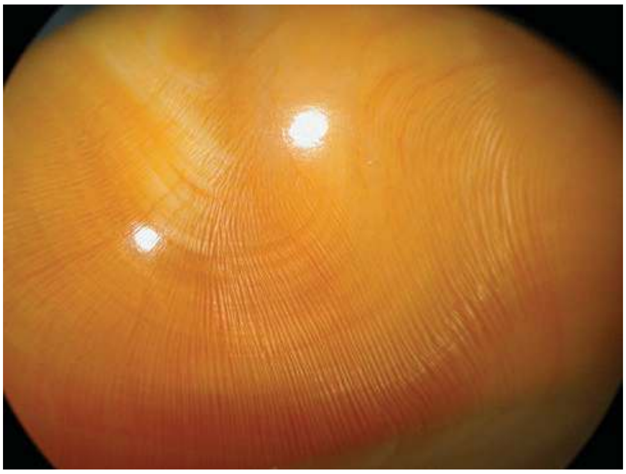

Figure 8: This polished Tridacna *shell bead (~23 × 16 mm or 63 ct) was dyed to imitate a Melo pearl. Note the well-developed flame structure, as would be expected for a genuine Melo pearl. Photo by M. S. Krzemnicki, © SSEF.*

Still, the media hype about such 'giant pearls' is worth highlighting, as it reveals the context in which modern urban myths are presented to the general public. For those who have read about several such 'giant pearl' discoveries, the themes sound very familiar. The stories include emotions such as greed and tragedy (a diver dies as he is trying to remove the 'pearl' from the giant clam but is stuck in the closing shell), unexpected discoveries but ignorance of their value (a poor fisherman finds the 'pearl' and keeps it as a personal item without knowing its 'true' value) and fairy-tale endings that involve achieving wealth and fortune and, hopefully, happiness (finally the 'giant pearl' is appraised by some unknown source as being of enormous value—for example, US$100 million—with an open ending as to how much money the poor fisherman will actually obtain). Although such stories may be entertaining and intriguing, the same themes have been used and repeated with great detail since historic times (Kunz and Stevenson, 1908, p. 144), mostly to create illusion and interest in such exotic 'oddities'.

Unnoticed by the media, but occasionally encountered in the laboratory and reported in the gemmological literature, are smaller fake pearls that most probably have been cut and polished from *Tridacna* clams (Disner and Notari, 2015). In the past few years, SSEF has analysed a few such specimens, cut into roundish shapes and sizes typical for gastropod pearls (e.g. Figure 7). They were polished with great care to display their fine flame structure and perfectly shaped to fit into jewellery. As such, they have been mistakenly bought as non-nacreous natural pearls, even by knowledgeable pearl dealers. Moreover, these manufactured 'pearls' may be dyed orange to imitate Melo pearls (Wentzell, 2006; Sturman et al., 2011; Figure 8). Raman spectroscopy of one such Melo imitation showed no peaks at 1134 and 1527 cm^{-1} characteristic of the natural-colour pigment in Melo (and conch) pearls, but did reveal three broad features at 1519, 1499 and 1363 cm^{-1} that closely matched the broad Raman peaks of organic dye (possibly red eosin; Krzemnicki, 2006).

Conclusions

Based on our observations and analyses, the five specimens submitted as 'pearls' reportedly originating from giant clams were identified unambiguously as beads cut and polished from *Tridacna* shell. The main criterion for the detection of all these fake pearls was the presence of distinctly discernible shell layers (sometimes overprinted by fine flame structures).

Considering the similarity of these specimens to numerous other items on the Internet or in pictures sent to us, we assume that most of these others also are fakes, and as such have essentially no commercial value. This is very much in contradiction to media reports or dubious appraisal documents, which unfortunately are too often reproduced and relinked by reputed news sources without question.

It is also important to reiterate that *Tridacna* clams are endangered species listed in Appendix II of CITES (2016) and therefore are protected. Any international trade of shells or pearls from *Tridacna* requires an official permit before export. As such, trade organizations actively have banned the use of *Tridacna* shell beads in jewellery or as beads for pearl cultivation in recent years (Zhou and Zhou, 2015).

And, finally, this study reminds us of the ingenuity of mankind to create illusion and garnish fraud with an appealing myth. The authors hope that with this article, the chapter on the so-called 'giant pearls' from *Tridacna* clams can be closed, at least in the gemmological community.

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