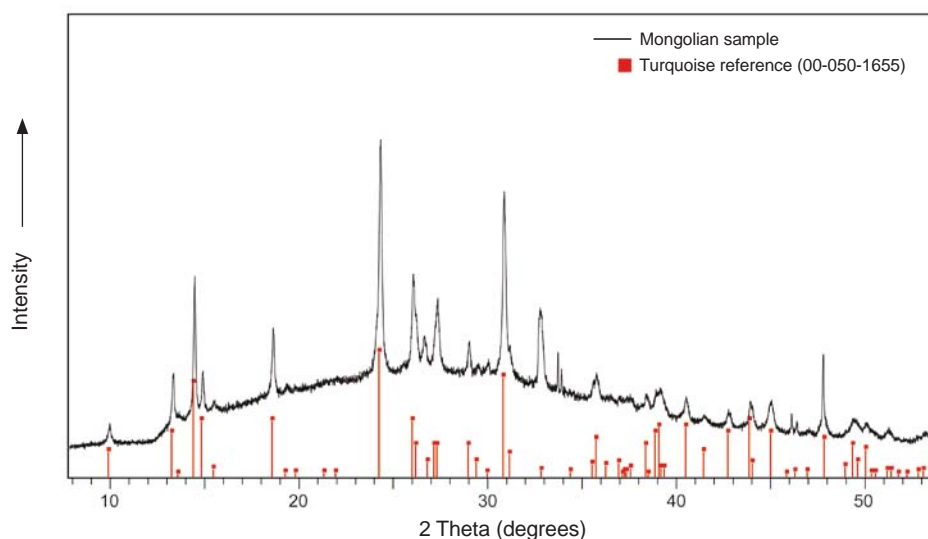


## X-ray Diffraction Pattern



**Figure 16:** The powder X-ray diffraction pattern of the Mongolian material confirms its identity as turquoise.

by Fe and As, which were detected by EDXRF and have larger ionic radii than Cu ( $^{VI}\text{Fe}^{2+} = 0.78 \text{ \AA}$  vs  $^{VI}\text{Cu}^{2+} = 0.73 \text{ \AA}$ ) and P ( $^{IV}\text{As}^{5+} = 0.34 \text{ \AA}$  vs  $^{IV}\text{P}^{5+} = 0.17 \text{ \AA}$ ).

Rough turquoise from Mongolia is available on the domestic market, where it is being sold by the company that is mining the deposit (Erdenet Mining Corp.).

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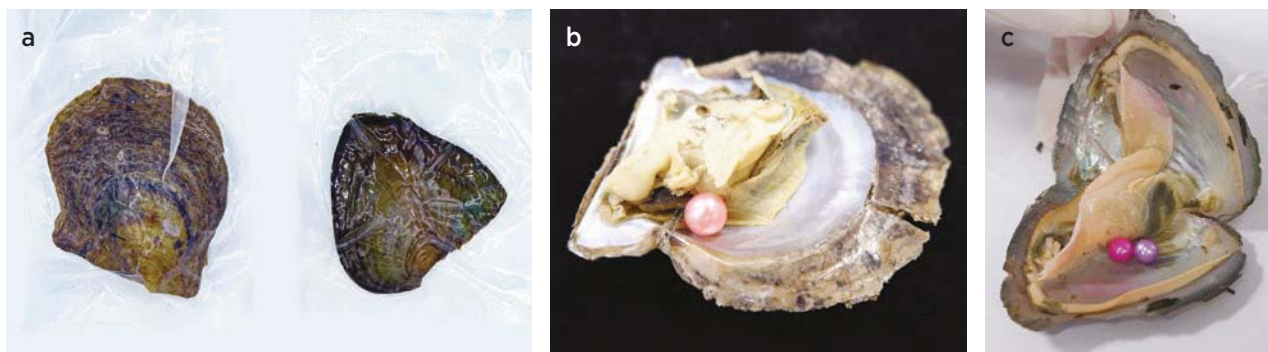
## PEARLS

## Molluscs Artificially Filled with Cultured Pearls of Various Colours

In recent years, cultured pearls of various colours have become widespread in online marketplaces and social media sales channels—in some cases via streaming to a live audience. Recently, some sellers began offering pearl-producing molluscs in vacuum-sealed packages,

which buyers unseal and open themselves to reveal cultured pearls of various colours. In most cases, these products are advertised as saltwater oysters containing pearls with more than 50 possible colours.

We purchased 23 of these molluscs from various



**Figure 17:** (a) A saltwater *Pinctada* sp. mollusc (left) and freshwater *Hyriopsis* sp. mussel (right) are shown here in vacuum-sealed packages that are representative of such products being sold online. A newly opened saltwater mollusc (b) and freshwater mussel (c) reveal that the cultured pearls they contain are not implanted in the gonad or mantle, respectively, but appear to have been placed in the shells after being previously harvested. Note also the artificial colour appearance of the cultured pearls and the lack of corresponding colouration in the nacre of the shells. Each shell measures approximately 5 × 6 cm; photos by M. Seneewong-Na-Ayutthaya.

e-commerce platforms based in China. They turned out to consist of 16 saltwater molluscs and seven freshwater mussels (e.g. Figure 17a). Upon opening them, we found a total of 28 cultured pearls measuring 6.20–8.10 mm in diameter and weighing 1.80–3.50 ct. They showed various colours: white, cream, yellow, orange, pink, purple, brown and blue (e.g. Figure 18). Most of the colours were quite unnatural and indicated a dyed origin, and this was supported by microscopic evidence (e.g. uneven colouration and residues concentrated along surface-reaching fractures).

Pearls typically grow in either the gonad (saltwater mollusc) or mantle (freshwater mussel) tissues, regardless of whether they form naturally or are cultivated with human intervention (Cartier *et al.* 2012). However, in the mollusc samples we acquired, they were not found in either the gonad or mantle areas. Instead, it was clear they had been placed into the shells after being previously harvested (Figure 17b, c).

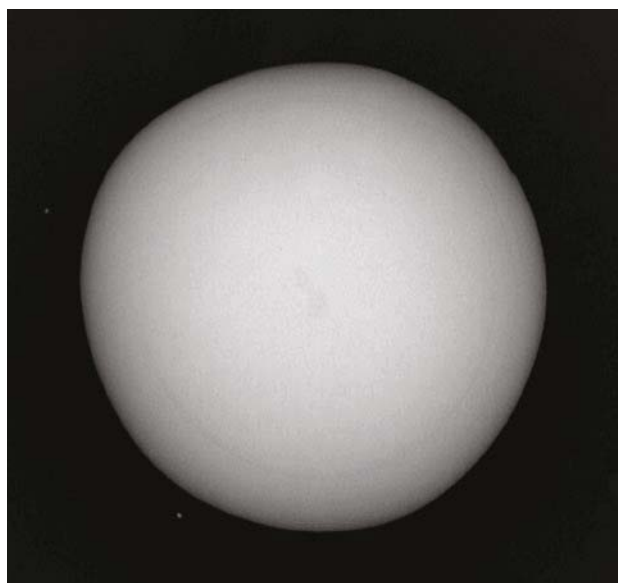
X-radiography revealed that all of our samples (from both the freshwater and saltwater molluscs) were

non-beaded freshwater cultured pearls (e.g. Figure 19). EDXRF analyses yielded 0.12–0.52 wt.% MnO and 0.32–0.70 wt.% SrO; the SrO/MnO ratios of 0.35–3.50 were consistent with a freshwater origin for these cultured pearls (cf. Abduriyim 2018).

Raman spectroscopy showed peaks at 1085 and 706  $\text{cm}^{-1}$ , which indicate that aragonite/calcite is the major constituent of these cultured pearls. Natural-colour cultured pearls of freshwater origin with orange, pink and purple colouration often show Raman bands at 1532 and 1134  $\text{cm}^{-1}$  related to their organic pigments (Otter *et al.* 2017). By comparison, the present cultured pearl samples (which showed brighter, unnatural colours) did not produce any such Raman bands, consistent with being artificially dyed. In addition, UV-Vis reflectance spectroscopy of our yellow, blue, pink and purple samples also showed evidence of dyeing (Figure 20). Only the yellow sample possessed a colour that could be found naturally, but it displayed a prominent absorption band at around 450 nm that is known to occur in dyed deep yellow to golden coloured cultured pearls (Kwak *et al.* 2016).



**Figure 18:** Various colours—some of them quite artificial in appearance—are exhibited by these selected cultured pearls (6.20–8.10 mm in diameter) that were recovered from the mollusc samples acquired from online sellers. Photo by M. Seneewong-Na-Ayutthaya.



**Figure 19:** X-radiography of the samples obtained in this investigation showed that they all were non-beaded freshwater cultured pearls, as shown by this 6.55-mm-diameter example. Image by M. Seneewong-Na-Ayutthaya.

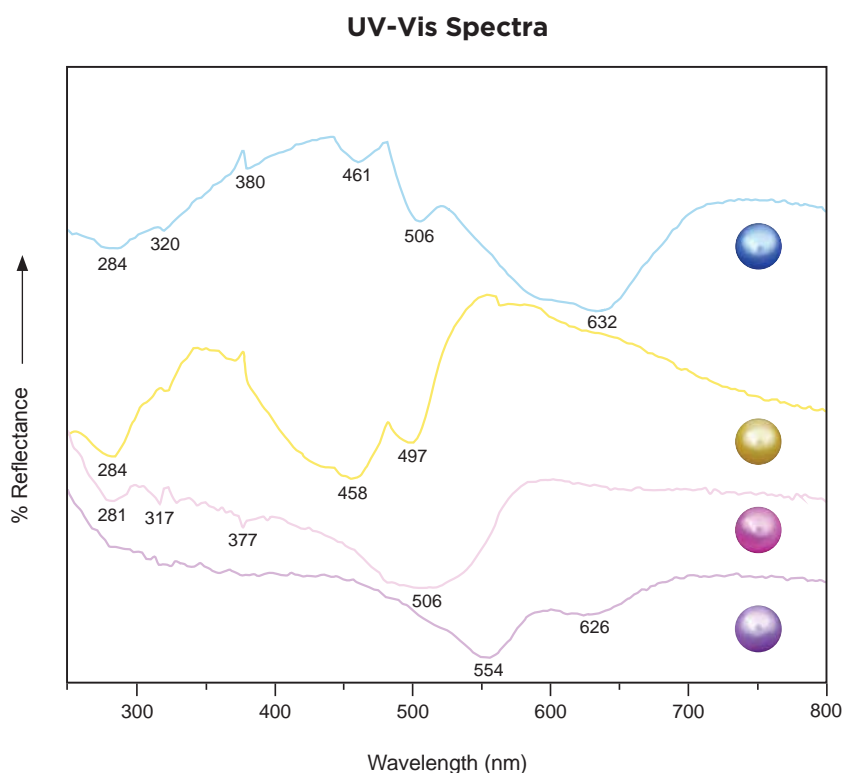
Regardless of the saltwater or freshwater origin of the mollusc samples obtained for this study, they were all found to contain non-beaded freshwater cultured pearls, most of which were dyed. The marketing

strategy of these products gives a misleading impression to the consumer that they are saltwater cultured pearls which were produced by the molluscs containing them. Even though the cultured pearls can be personally ‘collected’ from these molluscs, this clearly does not preclude them from being dyed (or natural-coloured) products that were inserted into the shells after being previously harvested.

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**Figure 20:** UV-Vis reflectance spectra were collected from selected cultured pearls (blue, yellow, pink and purple) that were removed from the molluscs obtained for this study. Only the yellow sample shows a natural-looking colour, but the prominent absorption band at around 450 nm is typical of dyed deep yellow to golden cultured pearls.