

Radiocarbon ^{14}C dating of pearls:

From the study of cultural heritage
to cultured pearl identification



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Historical background

Shells, among the most ancient Jewels of Mankind



Approx. 75,000 and 72,000 years old shell beads of the marine gastropod *Nassarius kraussianus* from Blombos Cave in South Africa.



Scientific discussion:

Prehistoric shell beads as a window on language evolution, a critical review by R. Botha, 2008

Historical background

Pearls in History

Umm Al Quwain



Saltwater natural pearl from Umm Al Quwain excavations, **approx. 7500 years old** (dated from ash layers).

Charpentier et al., 2012

Australia

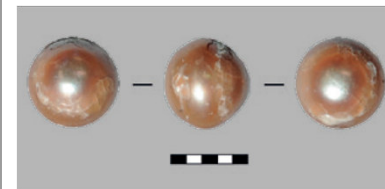
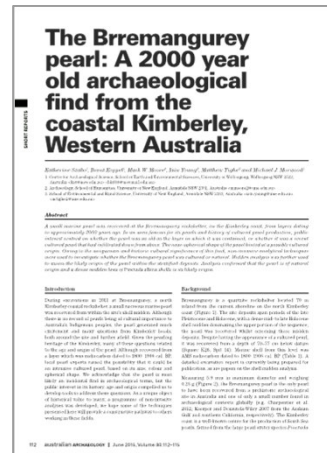


Figure 2 The Brremangurey pearl. Scale bar is in millimetres.

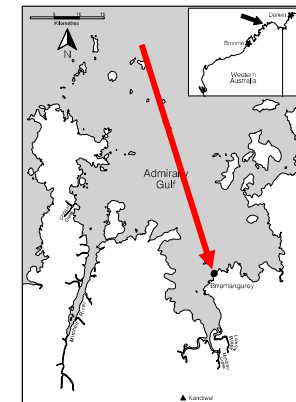


Figure 1 The location of the Brremangurey site on the shore of the Admiralty Gulf, northern Western Australia.

Freshwater natural pearl from North-Western Australia, **approx. 2000 years old** (dated from radiocarbon ages of shells in excavation).

Szabo et al., 2015

Historical background

Pearls in History



“[Pearls] occupied the first rank...and the very highest position among valuables.”
Pliny, *Historia Naturalis*



The Cowdray Pearl Necklace and painting of Annie Pearson, Viscountess Cowdray



Cleopatra and the pearl
A. Schoonjans (1655-1726)



Girl with a pearl ear ring
J. Vermeer (1632 - 1675)



La Peregrina pearl

Pearls in modern Jewellery

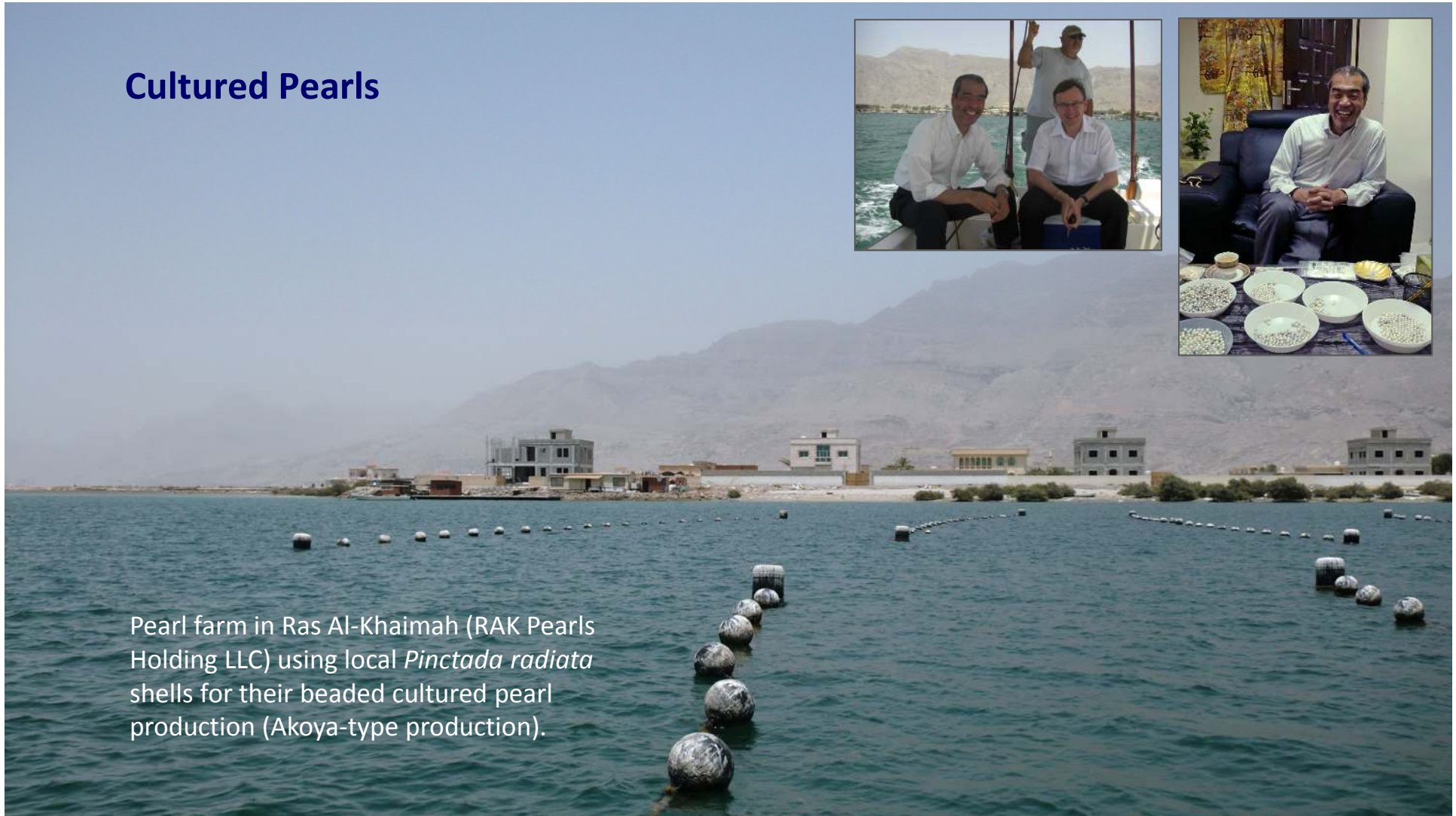
New pearl designs in modern jewellery
and re-use of old (natural) pearls in new settings or strands.



Cultured Pearls



Pearl farm in Ras Al-Khaimah (RAK Pearls Holding LLC) using local *Pinctada radiata* shells for their beaded cultured pearl production (Akoya-type production).

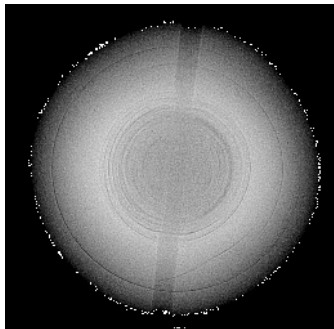


Pearl Testing for the Trade

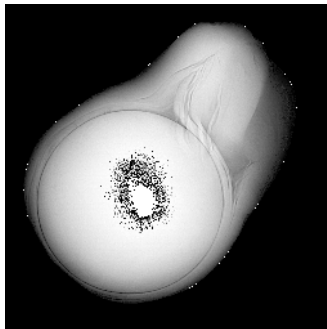
Separation of Natural Pearls from Cultured Pearls

Traditionally based on interpretation of internal structures, visualized by X-ray radiography.

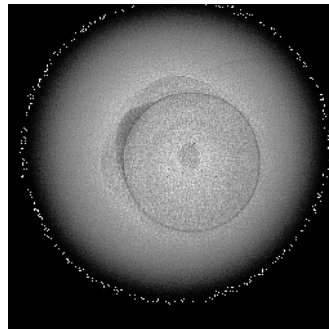
Natural



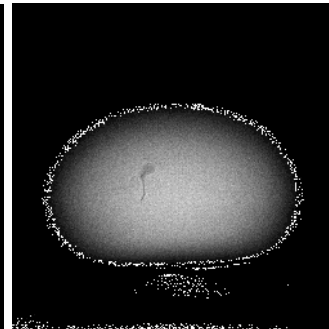
Cultured with shell bead



Cultured with natural pearl bead



Cultured with no bead



Natural pearl dealer in Bahrain

Further questions: Freshwater or saltwater pearl ? Treated or not ? Species ? Geographic location ?
.....and age of pearl ?

Pearl Testing for the Trade

Structure of a Natural Pearl

Tabular aragonite
= Mother-of-Pearl (nacre)

Columnar calcite

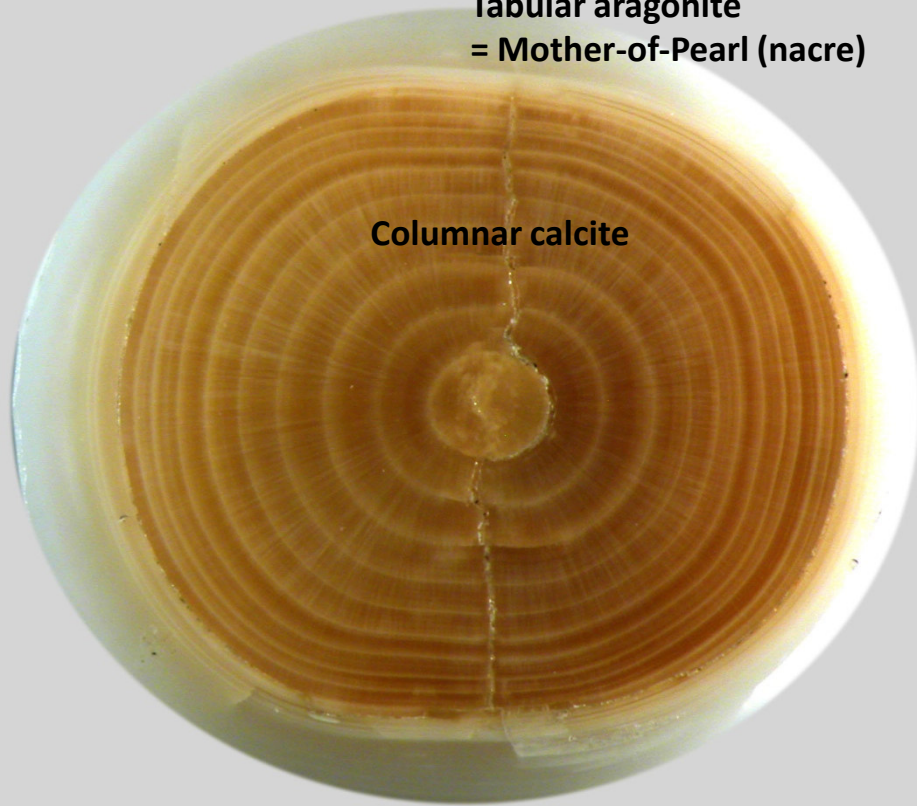
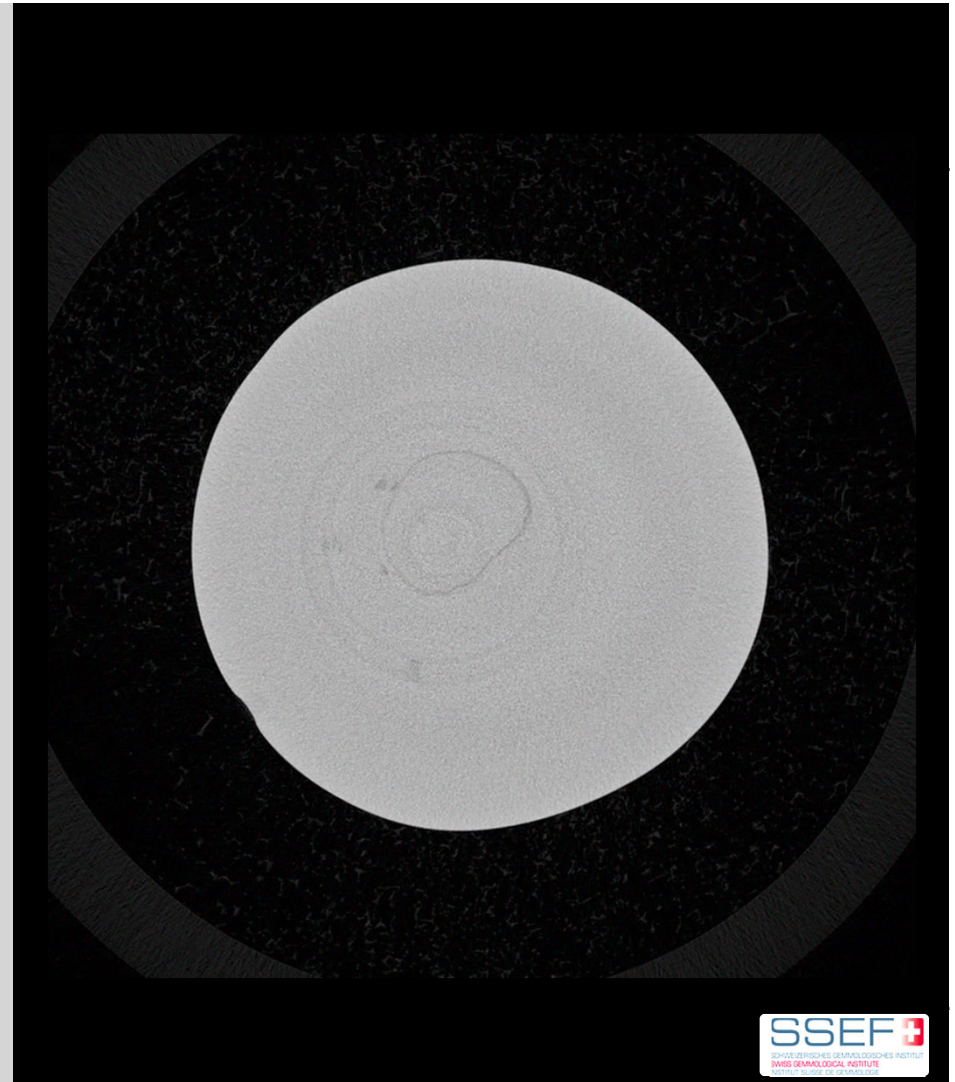
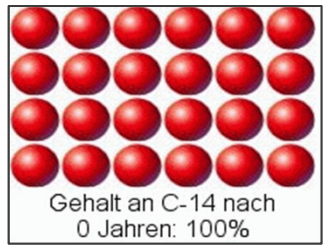


Foto H.A. Hänni, SSEF



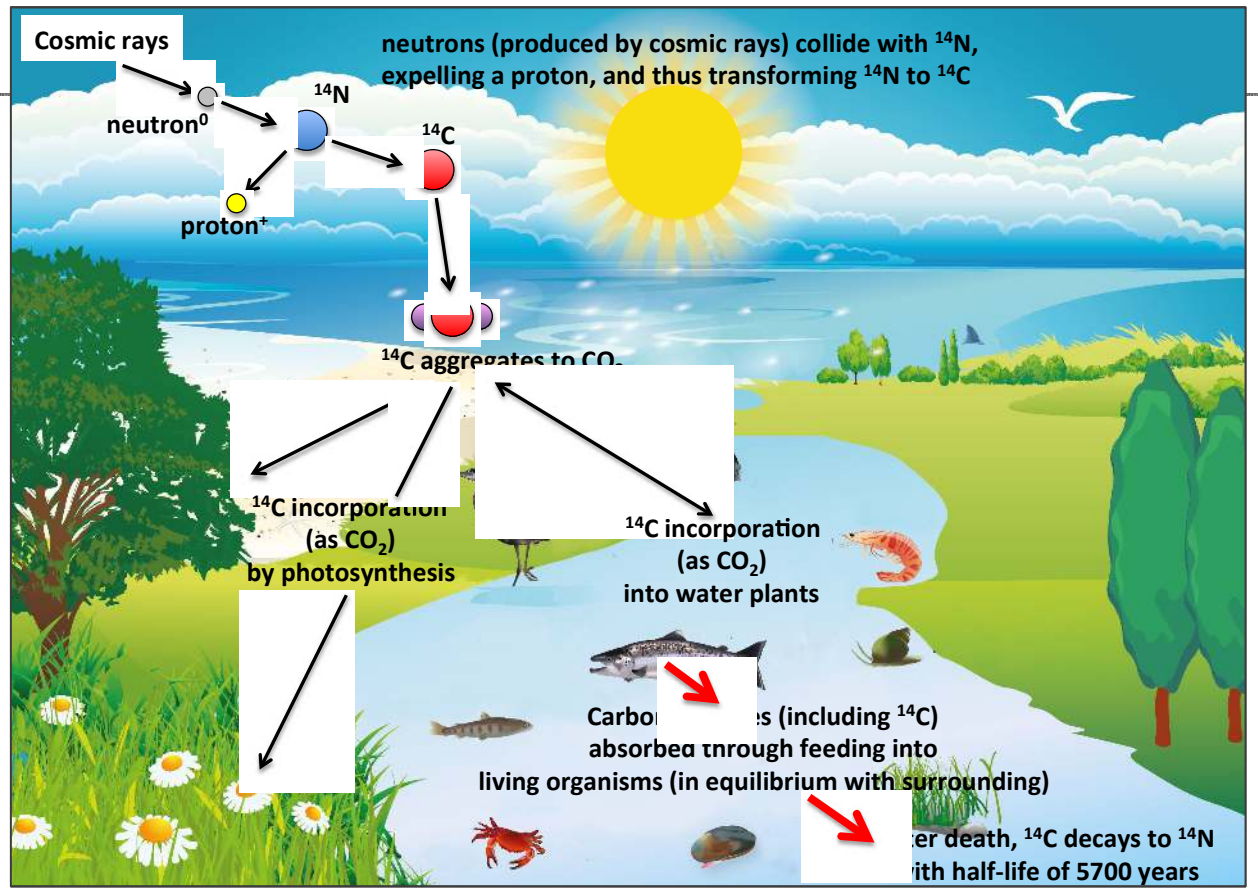
Radiocarbon Dating of Pearls

Radiocarbon Cycle



A pearl is nearly 100% **calcium carbonate** interlayered with some organic matter and formed by biomineralization processes.

Figure © M.S. Krzemnicki, SSEF using background from website of Inland Fisheries Ireland.



Radiocarbon Dating of Pearls Sampling

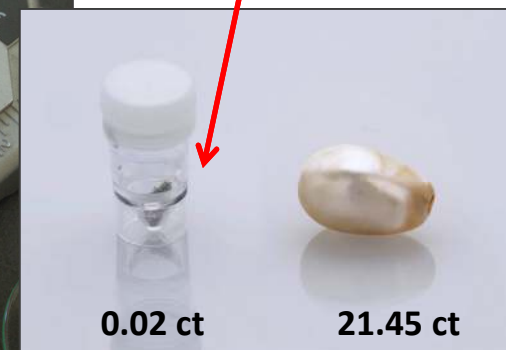


A minute amount (less than 0.004 g) of calcium carbonate is taken from inside the drill-hole.

„quasi“ non-destructive testing even for objects of archaeological and cultural heritage.

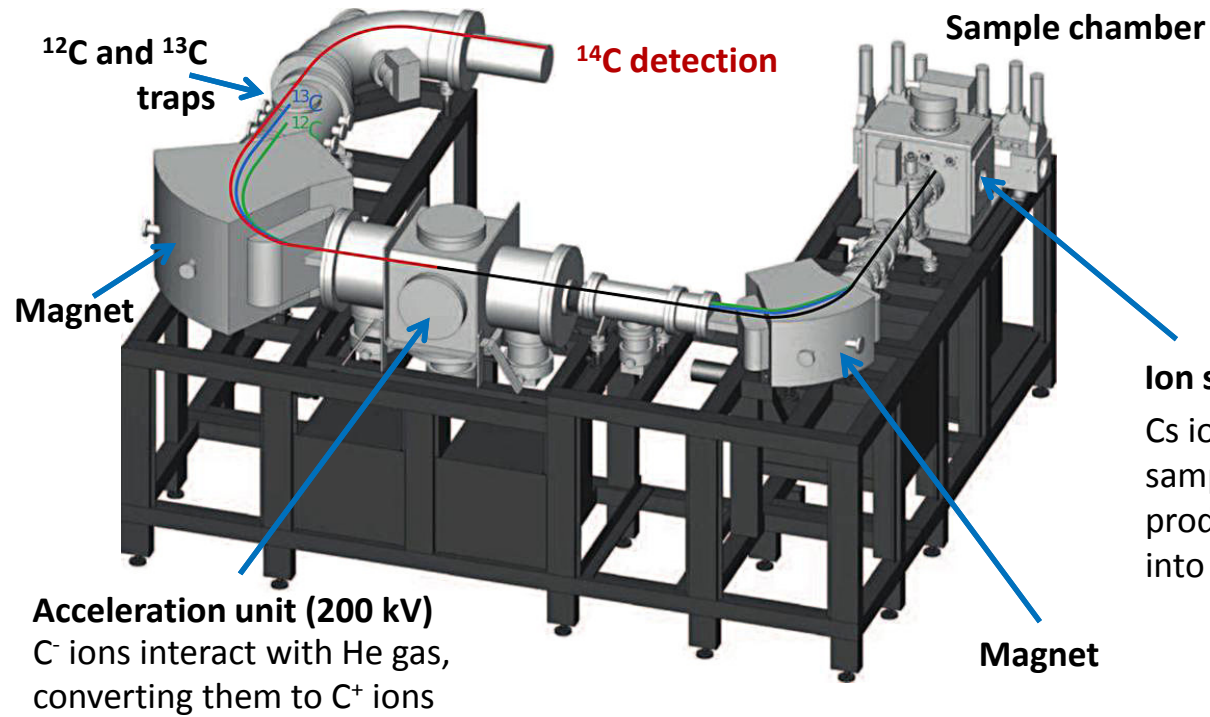


0.02 ct powder of calcium carbonate for age dating.



Radiocarbon Dating of Pearls **MICADAS (AMS)**

Mini Carbon Dating System (Accelerator Mass Spectrometer)



Ion source

Cs ions interact with graphitized sample or CO₂ sample gas, producing C⁻ ions, which are fed into the accelerator unit.

Images courtesy ETH Zurich & ionplus AG

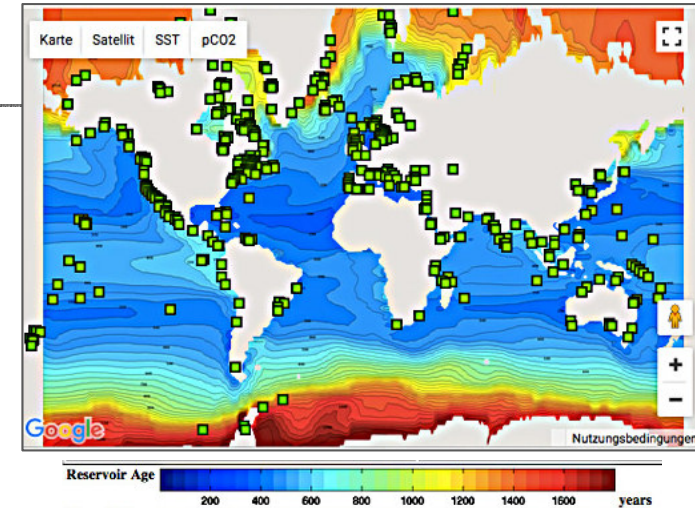
Challenges: Data Correction and Interpretation

Water reservoir age (old age effect)

Analysed raw data has to be corrected for reservoir age. This means that the geographic location of the pearl should be known (at least approximately).

Contamination with geological calcium carbonate and diagenesis

Difference between suspension feeder (e.g. Pinctada molluscs) and Soil grinding feeder (e.g. haliotis or other gastropods).
Difference between material from excavations and “fresh” shells/pearls in jewellery

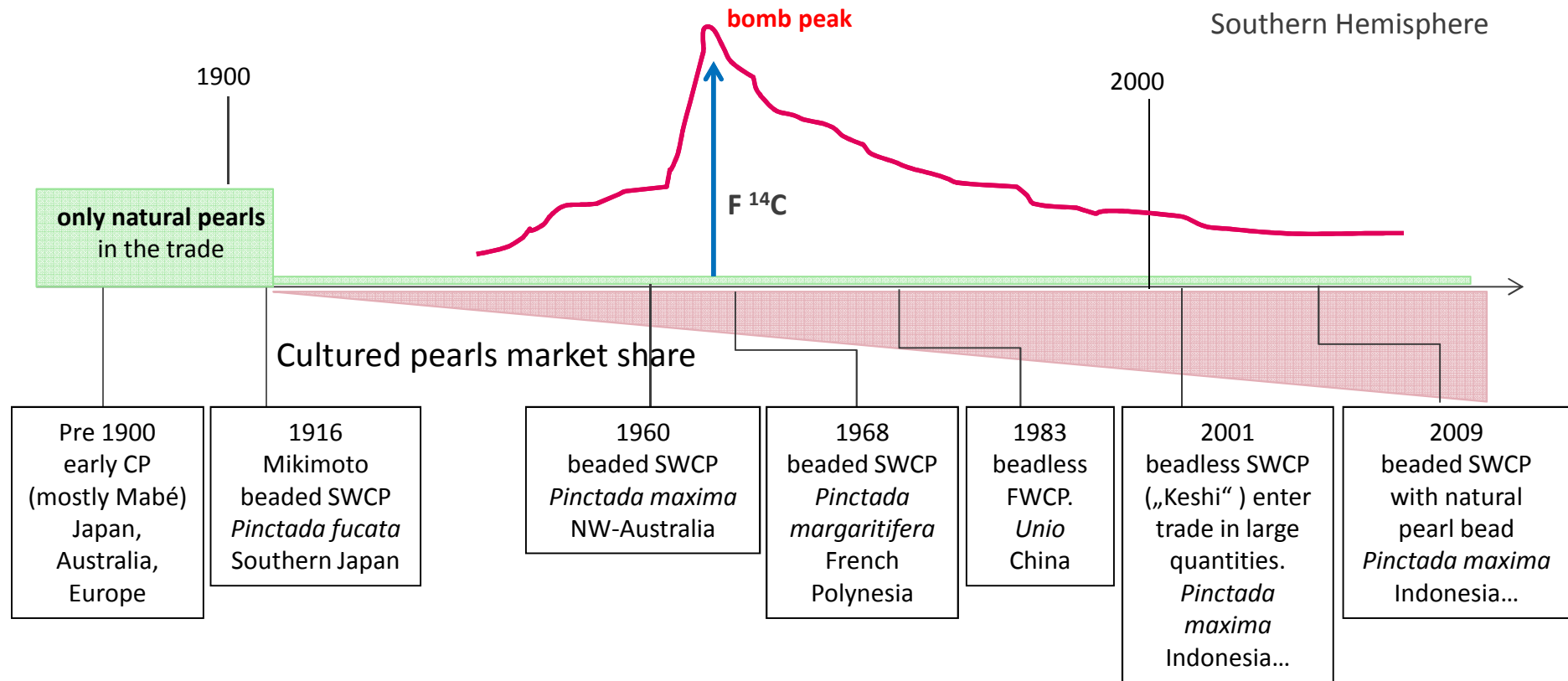


http://radiocarbon.ldeo.columbia.edu/research/resage/res_ff.cgi

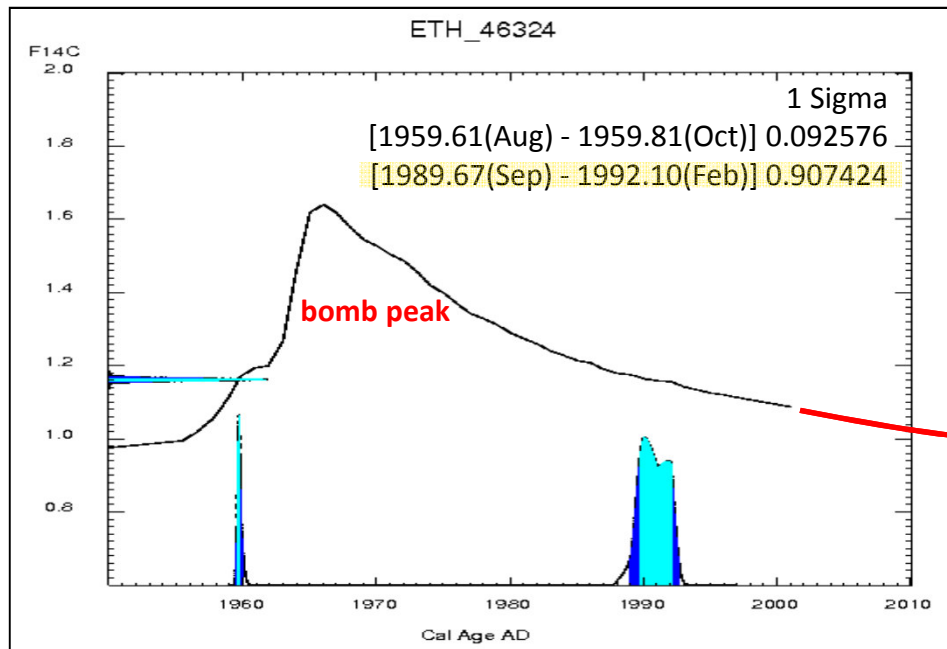
Important: The data has to be interpreted (plausibility check) !

Radiocarbon Dating of Pearls

The Bomb Peak



Radiocarbon Dating of Pearls Recent Shell

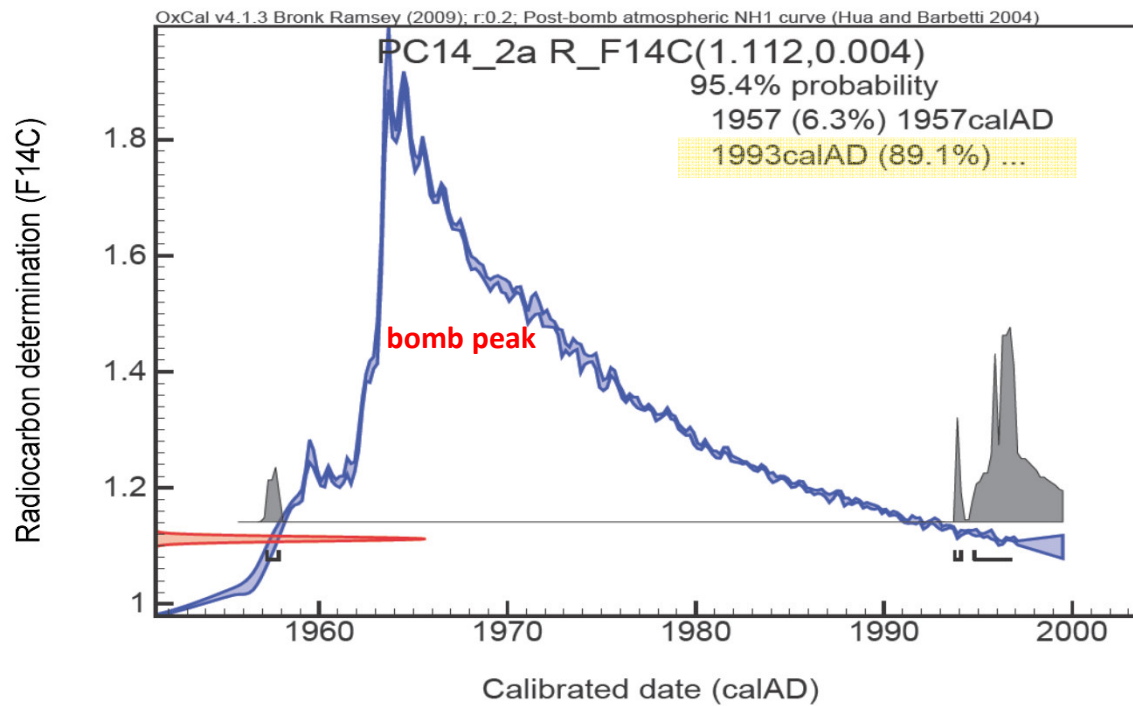


Shell (*Pinctada maxima*; silverlip pearl oyster) from the Philippines, collected 1990 (pers. comm. H.A. Hänni)



Radiocarbon Dating of Pearls

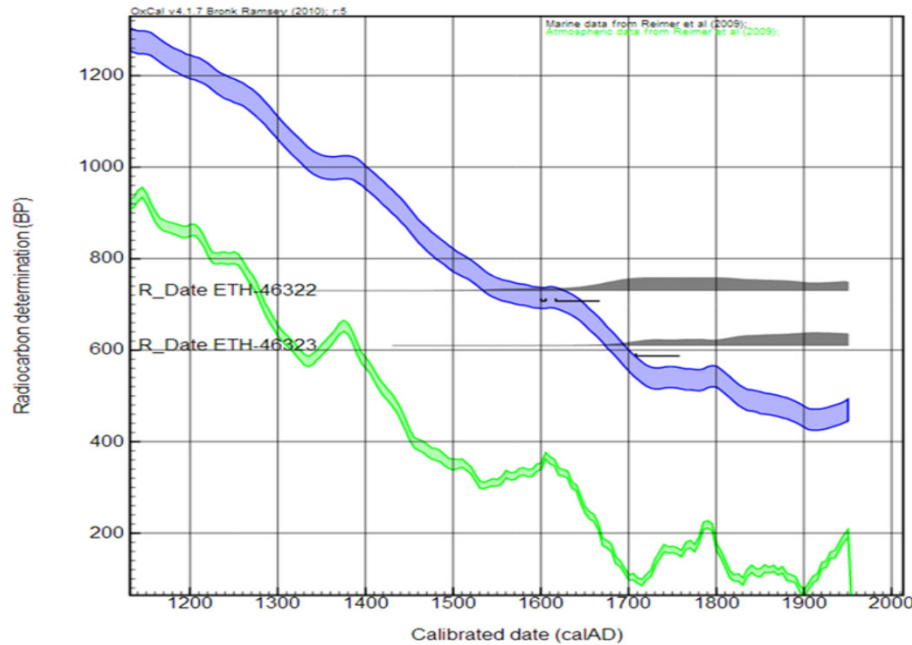
Recent Pearl



Beadless saltwater cultured pearl from *Pinctada maxima* from Indonesia, collected approx. 1995 (pers. comm. H.A. Hänni)

Radiocarbon Dating of Pearls

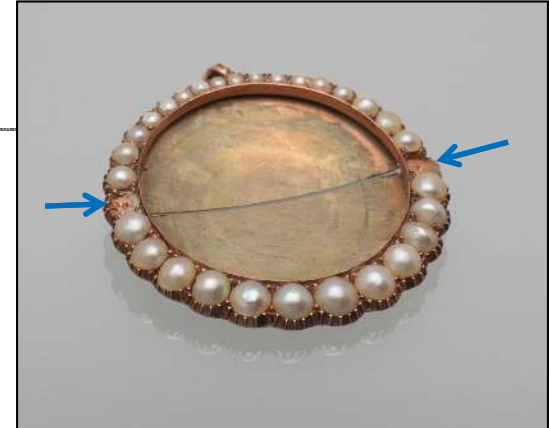
Historic Pearl



ETH-46322 :

68.2% probability
 1680 AD (20.9%) 1740 AD
 1750 AD (1.1%) 1770 AD
 1800 AD (7.8%) 1820 AD
 1830 AD (27.0%) 1890 AD
 1910 AD (11.4%) 1940 AD

95.4% probability
 1670 AD (37.9%) 1780 AD
 1790 AD (57.5%) 1950 AD

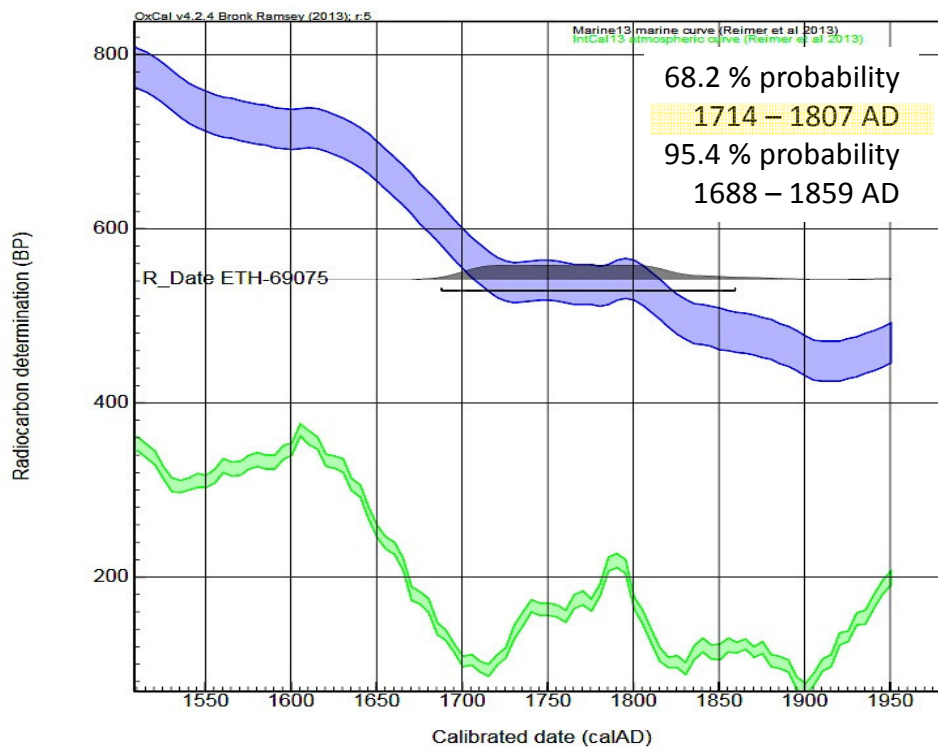


Two pearls from *Pinctada radiata*, assumed to be from the Arabian Gulf. Originally set in an antique pendant from mid-19th century (pers. comm. T. Färber, Geneva).

Problematic time of the calibration curve where multiple intervals correspond to the measured ¹⁴C age.

Radiocarbon Dating of Pearls

Historic Pearl



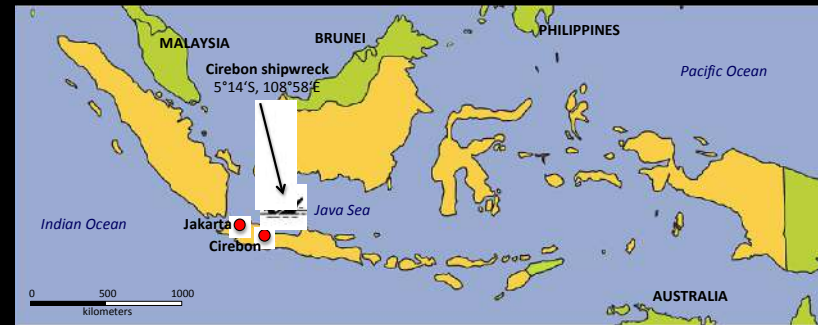
Ear-pendants with large historic pearls from *Pinctada maxima* assumed to be from coastal waters in Southeast Asia.

Radiocarbon Dating of Pearls

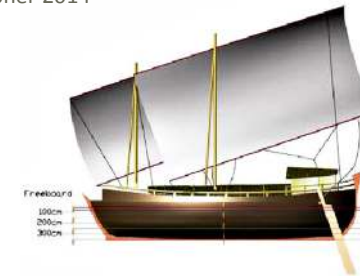
Pearls from the Cirebon Shipwreck



1000 year old pearls from the Cirebon ship-wreck,
discovered in 2003 in the Java Sea (Indonesia).

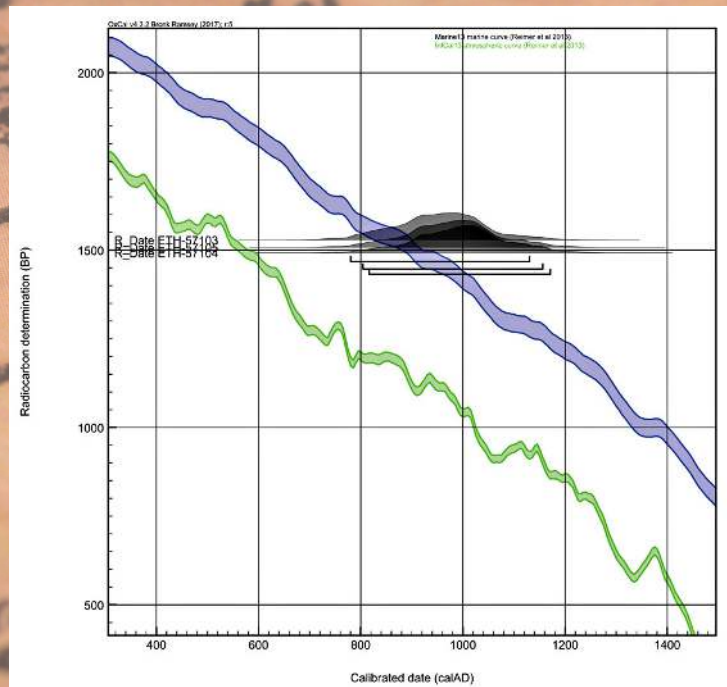


Liebner 2014



Radiocarbon Dating of Pearls

Pearls from the Cirebon Shipwreck



The ^{14}C ages perfectly fit with the archaeological dating of this shipwreck based on pottery and coins.

Radiocarbon Dating of Pearls

Cirebon and the historic “maritime Silk Road”



G.M.A.W. Lodewijcksz, 1598



cirebon.musee-mariemont.be/the-wreck



The Cirebon merchant vessel was part of a peddler trade along the “maritime Silk road”, connecting East-Africa (and Madagascar), the Middle East, India, Southeast Asia with China.

The age of the wreck corresponds to an era of upheaval in China called the „Five Dynasties and Ten Kingdoms“ (ca. 907 – 979 AD., Lorge 2011)



map slightly adapted from P-Y. Manguin, 2017

See also our publication in the next Journal of Gemmology

Conclusions

- Radiocarbon dating of pearls is possible with minute sampling (0.02 ct) “quasi non-destructive”.
- Radiocarbon dating of pearls requires reservoir age corrections, thus the approximate geographic location of the shell/pearl should be known.
- Clear distinction possible between modern pearls (>1950) and older or historic pearls (pre 1950), and as such it may also support natural / cultured pear identification.
- Age dating of pearls offers new insight in historical provenance of antique jewellery, but also helps to identify forgeries.
- The 1000 years old Cirebon pearls are so far the oldest pearls dated directly from their nacre.
- Several on-going research projects on pearls and shells from archaeological excavations, on antique jewellery from Renaissance to Baroque era and on modern cultured pearls from Australia.
- SSEF offers radiocarbon dating of pearls as a service to our clients from the pearl trade in collaboration with the Laboratory for Ion Physics, ETH Zurich.



Thank you for your attention



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Publications:

Krzemnicki & Hajdas (2013)
Radiocarbon, Vol 55, No. 2–3,
p 1801–1809.

Krzemnicki et al (2017). Journal of
Gemmology, Vol 35, No. 8 (in print)

