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The Identification of Dugong Ivory Reel Artefacts from Strontium Content and Microstructure

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ABSTRACT

A series of reel necklace units were found in an archaeological site on Taumako, a Polynesian Outlier in the Solomon Islands, and are dated to about A.D.1500. The grinding and shaping of these reels during manufacture has obscured most of the gross anatomical features that might aid the identification of the original type of tooth ivory. A comparative study by means of scanning electron microscopy of samples of ivory from nine species of animals revealed that most of the artefacts had features most compatible with the marine sea cow *Dugong dugon*. The strontium/calcium ratios of dugong ivory, as determined by energy dispersive X-ray fluorescence analysis, was about three times that of other animals. Most of the artefacts appeared to be made from the upper central incisors of juvenile dugong, while a single large reel was almost certainly made from sperm whale ivory.
Keywords DUGONG, STRONTIUM, IVORY ARTEFACTS, XRF, SEM.

INTRODUCTION

During recent excavations of a burial mound known as Namu (SE-DF-14) on Taumako in the Solomon Islands about 100 reel-shaped ivory artefacts were found. These units lay in close association with human burials in positions which indicated their use as necklaces, anklets and wristlets. The site has been radiocarbon dated to about A.D.1500. The population on Taumako speak a Polynesian language, and as this high island lies well outside the Polynesian triangle, it is designated a Polynesian Outlier. Similar reel units have been found elsewhere in Polynesia: on nearby Tikopia (Firth 1951:Plate 2); in tropical Eastern Polynesia in the Marquesas Islands (Force and Force 1971:105, see also Suggs 1961:140) and on Atiu in the Cook Islands (Gruning 1937:Plate 17, Buck 1944:116), and in Tonga (Kaeppler 1978:Fig. 424, Force and Force 1971:150, 155). They are also known in the non-Polynesian islands of Fiji (Edge-Partington 1890:122) and Rotuma (Edge-Partington 1895:53). Similar reel units are also present at Moa-hunter sites in New Zealand (Duff 1956:Fig. 15E, Skinner 1974:Fig. 4.161) where they are most commonly rendered in dense cortical moa bone, but are sometimes made from stone or ivory. The Taumako examples were clearly made of ivory and it was considered important to try and identify the species involved, as suitable ivory-producing animals are rare in this area. Crocodiles are sometimes snared in streams on the island, and some

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of the smaller units could have been made from their teeth. One reel, however, was too large for this to be possible. Sea mammals are occasionally stranded on the island, and this was considered a more likely source of the ivory.

THE REEL UNITS

Two types of reel unit were found in the excavations (Fig. 1). The first type, of which only one example was found, is a very large unit, of a form most similar to examples from Moa-hunter sites in New Zealand, and from Tikopia and the Marquesas Islands. It has a biconical suspensory hole. Anatomical features such as cemento-dentine or dentino-enamel boundaries which might have assisted identification are absent. The material is dense and featureless when viewed under a low power stereoscopic microscope. The single unit recovered was considered too valuable to warrant the removal of even a small piece for examination under higher magnification.

The second type was quite numerous and considerably smaller. Despite much modification during manufacture, some of these reels retain identifiable anatomical features. In most specimens the suspensory hole has been formed by taking advantage of the pulp cavity of the tooth during drilling. A few reels had not been drilled but had been threaded along the open pulp cavity, which shows a triangular cross section rather like a pig tusk. In one or two cases small remnants of thin enamel can be seen, but by and large the units are composed wholly of featureless dentine or cementum. The diameter of the pulp cavity decreases only slightly over the length of each reel, which indicates that they had come from a long tooth. The apparent tooth size and the open pulp cavity strongly suggest a derivation from juveniles. This makes identification more difficult, as juvenile teeth from different species can appear rather similar. The extensive modification of the teeth by drilling precluded accurate identification from anatomical features alone.

SCANNING ELECTRON MICROSCOPY (SEM)

In view of the large number of small reels in the collection, it was considered worthwhile to sacrifice a piece from one broken unit for examination under SEM (Specimen 78.678). The sample was cut at right angles to the pulp cavity using a diamond rock-cutting saw, and roughly polished on a diamond lapping wheel. The sample was mounted on a Cambridge type aluminium stub with araldite, etched for five hours in 5% formic acid in 10% formalin, and cleaned in an ultra-sonic water bath for 30 minutes. The specimen was then dried and degassed for 24 hours in P_2O_5 under vacuum, and then coated with approximately 30nm of gold in a Polaron diode sputtering apparatus. Specimens of modern teeth from both male and female elephant seal *(Mirounga leonina)*, killer whale *(Orcinus orca)*, false killer whale *(Pseudorca crassidens)*, pig *(Sus scrofa)*, sperm whale *(Physeter catodon)*, alligator *(Alligator* sp.), crocodile *(Crocodylus porosus)*, elephant *(Elephas maximus)*, and male and female dugong *(Dugong dugon)* were prepared in an identical manner. Each specimen was examined and photographed at magnifications of 10, 200, 1,000, and 25,000. The most significant features seen were all in the range of 2 to 20μm. Magnifications of 200 and 1,000 were the most suitable for comparative purposes. In general, features were most obvious in enamel, less so in cementum, and least striking in dentine. Any growth lines present such as annuli were differentially etched and showed up as major topographical features. Most specimens clearly showed a rippled surface suggesting finer growth-related structures such as daily growth rings. The pattern and size of these ripples and of the various pits and holes were convincingly different from one animal to another. In the small reel unit (Fig. 2) a series of holes formed a complex interconnecting system throughout the ivory. The diameters of the lateral canals were quite regular at approximately 1 to 2 μm, while the vertical canals were more variable, ranging from 3 to 7 μm. These canals were probably occupied by the dentine-forming

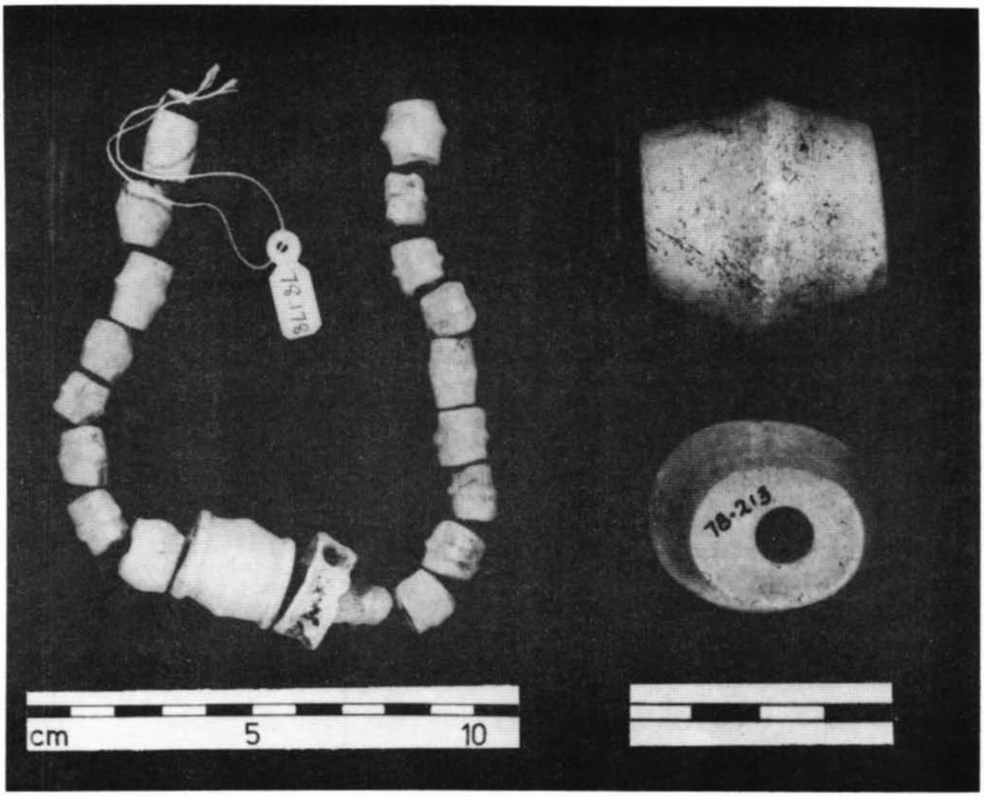

Figure 1 Specimens of ivory reel units from the Namu burial site in the Solomon Islands. The smaller units were found to be made from the central upper incisors of *Dugong dugon*, and the large unit from a tooth of *Physeter catodon*.

cells during life. Amongst the modern comparative samples, the pattern and dimensions of the canals and of the surface rippling in the archaeological specimen were seen only in the specimen of dugong. Other species showed far greater degrees of mineralisation, and some of the systems of shallow pits observed are suspected of being relics of similar passages which have been filled with dentine.

X-RAY FLUORESCENCE ANALYSIS (XRF)

To strengthen the above identification, it was decided to examine the chemical composition of the samples by energy dispersive XRF analysis. Particular attention was given to the levels of strontium (Sr), which is known to accumulate in the tissues and hard parts of some animals such as shellfish. It seemed possible that dugong Sr levels might be considerably different from those of other ivory-producing sea mammals since it is the only herbivore among them. In addition, since the method is non-destructive, the large reel unit (78.213) which was not examined by SEM could be examined by this technique. The system was set up with a molybdenum (Mo) target tube operating at 40 kV and 60 μA to give good sensitivity for the Sr peak. The main additional peaks observed were calcium (Ca), iron (Fe), zinc (Zn) and lead (Pb). The latter three elements did not prove to be particularly useful for discrimination of the different ivories. A typical specimen is shown in Figure 3. The peak ratios for Sr/Ca were calculated by area integration and the

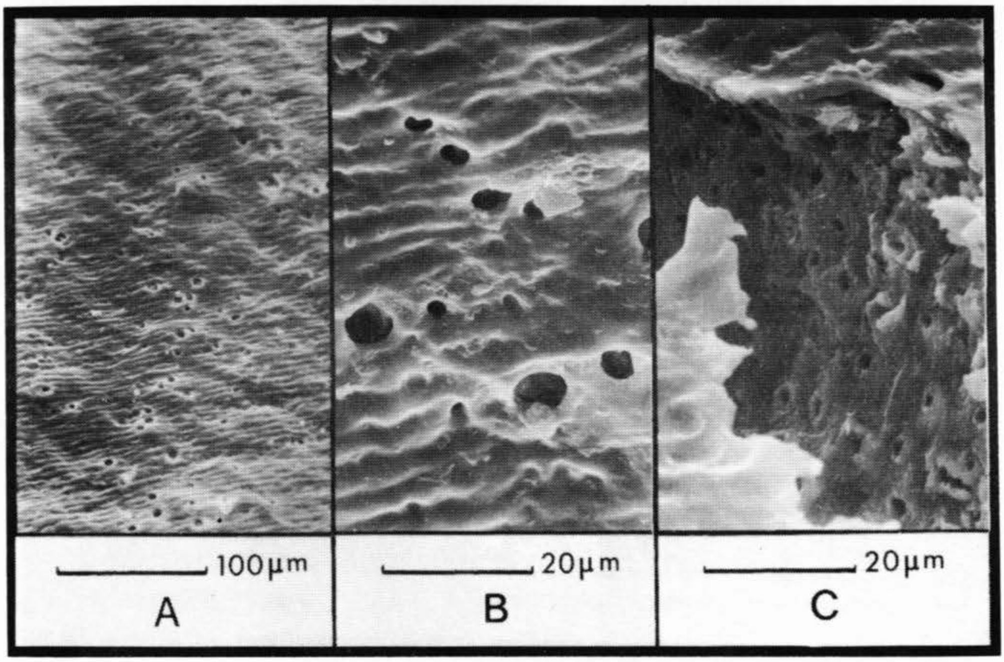

Figure 2 Scanning electron micrographs of one of the small ivory reel units. A: x 200, B: x 1000, C: x 1000. Note the surface rippling in A and B and the lateral interconnecting canaliculi in C.

results are illustrated in ascending order of magnitude in Figure 4. It can be seen that dugong has about three times the Sr/Ca ratio of other animals examined. The small ivory reels have closely similar values to that of dugong. The diameter of the large reel made either elephant or sperm whale ivory the most probable source material. Elephant ivory is extremely unlikely to occur in a prehistoric context in the Pacific, and therefore sperm whale was suspected. The reel produced figures compatible with sperm whale, and this was a thoroughly acceptable result.

CONCLUSION

The identification of the source of ivory used in the manufacture of artefacts is not a simple matter. However, attention to gross anatomical features and a combination of data on chemical composition and microscopic structure enable the type of ivory to be identified with some confidence. Dugong ivory is especially easy to identify since it has

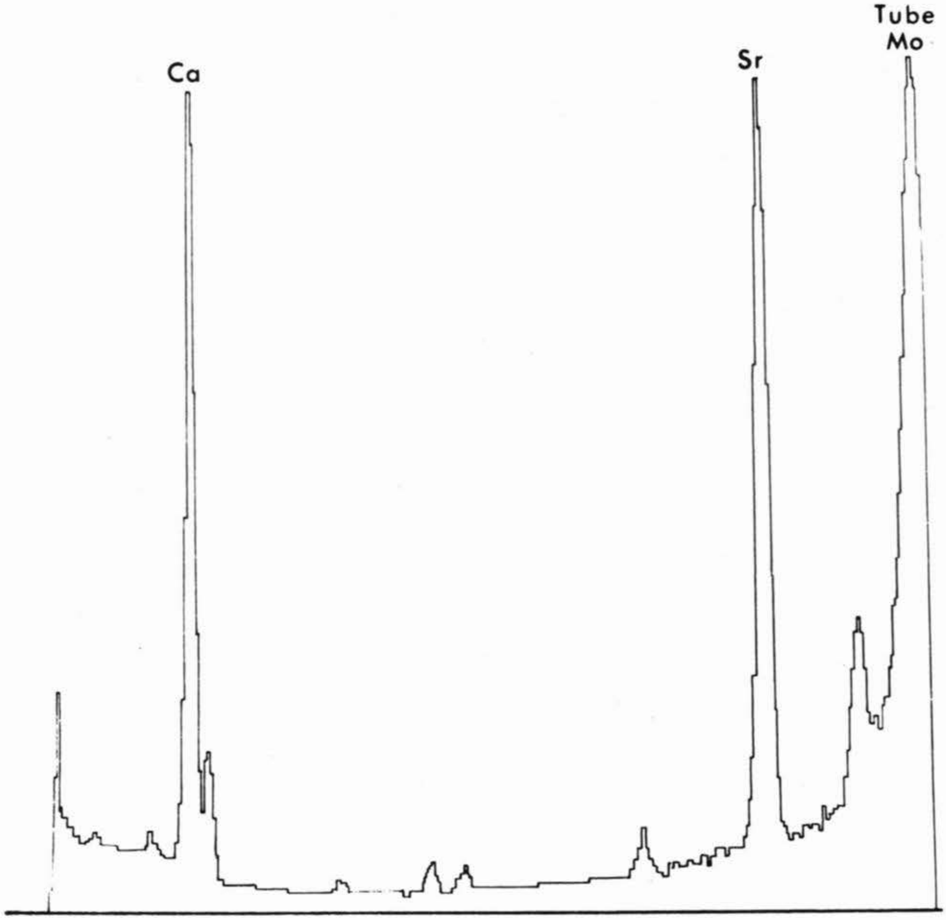

Figure 3 X-Ray Fluorescence Spectrum of one of the small ivory reel units. Note the very large strontium peak which is distinctive of *Dugong dugon*.

distinctive microscopic features and a Sr/Ca ratio content far higher than that of the other animals examined. The dugong has two large upper central incisors and a set of rather stubby molars. The incisors erupt through the gum only in males (Heinsohn and Marsh 1977:106), but in both sexes they are very large in the adult – about 3cm in diameter and up to 20cm in length (Mitchell 1973, 1978). They are, therefore, ideal for the manufacture of pendants and decorative units. The vestige of pulp cavity, present along the length of the tooth even in adults, makes it easy to drill out for suspensory cords. The bulk of each incisor is buried in the maxilla, and the cranium must be smashed to remove them. Dugongs are still killed for food in parts of the Solomon Islands today, as they doubtless were in antiquity. (For a description of dugong hunting near New Guinea, see Landtman 1927:120ff.) The size of the prehistoric reel units indicates that juvenile dugongs were more frequently caught than adults. The only large unit was clearly made from the tooth of a stranded sperm whale.

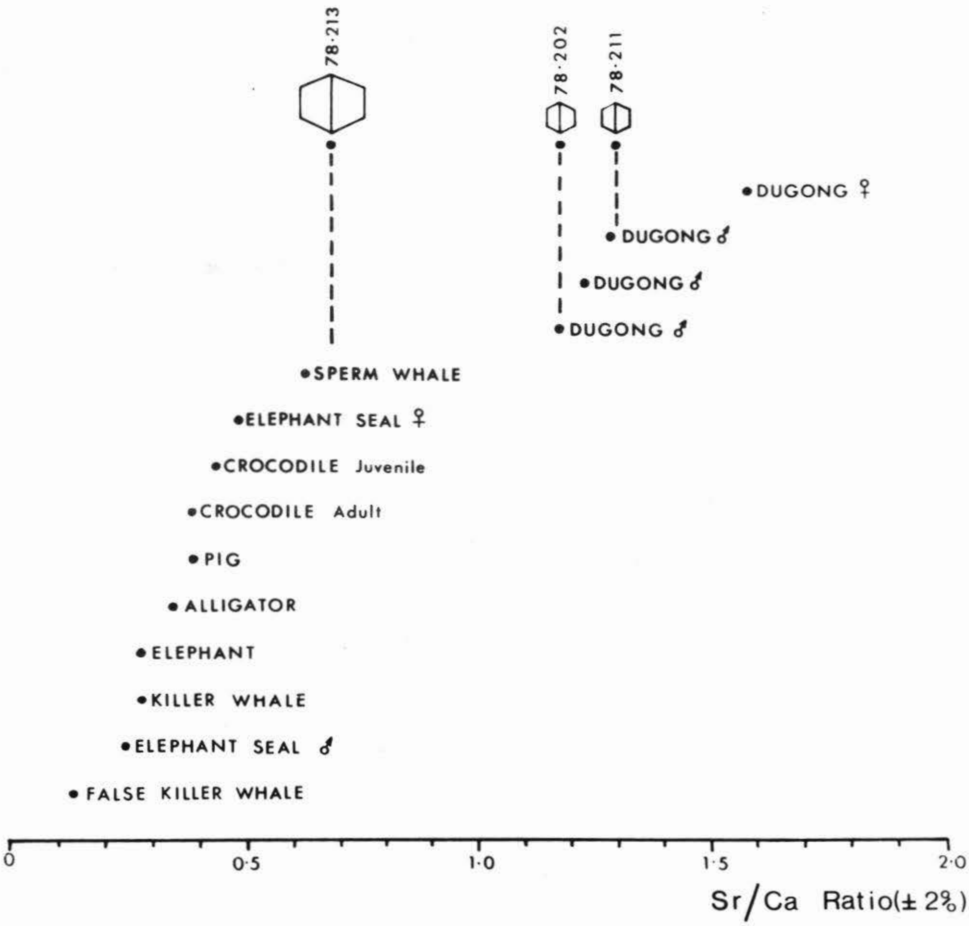

Figure 4 The peak ratio of Sr/Ca for three prehistoric ivory reel units and a series of modern tooth specimens from several species. The small reels are clearly *Dugong dugon*, while the large reel is closest to *Physeter catodon*. Note that the ratio scale is in arbitrary units as the efficiency of the detection of the two peaks varies from one instrument to another.

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