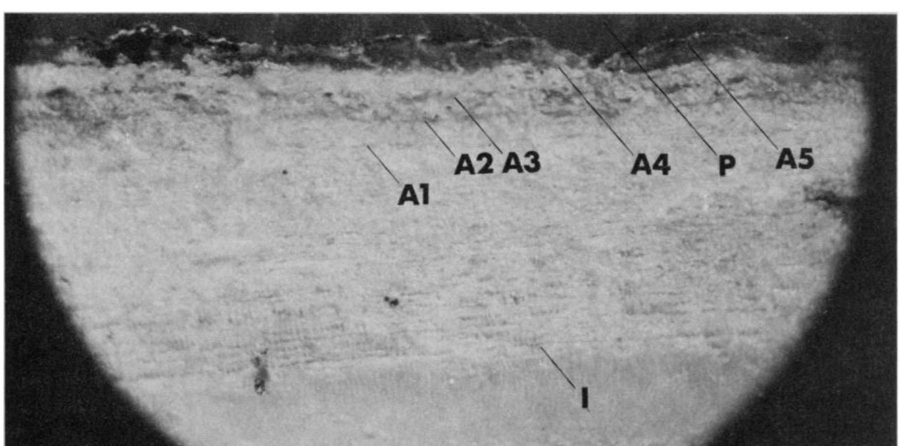
Reports

Determining the Season of Death of Mammal Teeth from Archeological Sites: A New Sectioning Technique

Abstract. *Alternating translucent and opaque bands on the roots of mammal teeth are used to determine the age and season of death. These structures are preserved in teeth from archeological sites. However, the standard sectioning technique, which includes decalcification, often destroys archeological specimens. A new, less destructive technique provides analyzable solid sections at costs comparable to decalcification.*

The determination of the season during which prehistoric sites were occupied has become a primary objective of faunal analysis. Current techniques used in these analyses include estimates from faunal remains of seasonal availability, season of birth, sequences of dental eruption, epiphyseal closure, and, in cervids, antler loss (*1*).

Recently Spiess reported a new technique for determining the season of death from archeological faunal remains (*2*). The technique is based upon the observation of incremental layers deposited seasonally in the cementum and dentin of many mammal teeth. Spiess's method was adapted from an age-determination technique developed by wildlife biologists. This technique includes decalcification in a 5 percent aqueous nitric acid solution, thin sectioning with a freezing microtome, and staining with hematoxylin to enhance contrast between layers. An alternate technique involves thin sectioning, as with mineral specimens. Both techniques require that the layering be examined microscopically.



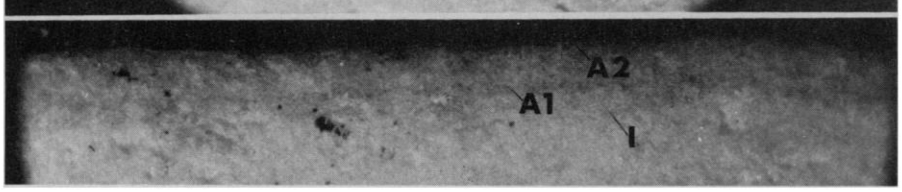


Fig. 1 (top). Longitudinal section of the fourth premolar of a black bear (*Ursus americanus*) from the Turner Farm site, showing cementum layers (photographed under reflected light at × 50). Above the dentin-cementum interface (*I*), alternating layers of cementum can be seen. Opaque layers (light under reflected light) are deposited during the summer months. Translucent layers (*A*) (dark under reflected light) are deposited during the winter months. Only the uppermost cementum layers are analyzable in this specimen. The most recent translucent layers are labeled *A1* through *A5*. The fully formed translucent layer on the outside of the tooth (*A5*) indicates that the bear died during late winter or early spring. The plastic mounting medium is *P*. Fig. 2 (bottom). Longitudinal section of a bison (*Bison antiquus*) incisor from the Jones-Miller site in Wyoming (photographed under reflected light at × 50). The dark layer forming on the outside probably indicates a winter kill. [Specimen courtesy of Denis Stanford, Smithsonian Institution]

The advantages of tooth sectioning, as a supplement to and independent check upon other seasonal indicators, lie in (i) the relative durability of mammalian teeth in archeological sites, (ii) the ease of identification to the genus or species level of most mammalian teeth, and (iii) the applicability of the technique to small faunal samples where other techniques fail for statistical reasons.

This project was begun because of Bourque's interest in determining the seasons of occupation at a specific site, the Turner Farm shell midden, North Haven Island, Maine. This site was occupied during six or more periods between about 5000 radiocarbon years ago and the early historic period (*3*). Large and well-preserved faunal samples from earlier components offered a unique opportunity to test hypotheses concerning the seasonality of late Archaic maritime zone exploitation in the region. Spiess's initial attempts to analyze teeth from the Turner Farm site, using the decalcification-thin-sectioning technique, led to nearly total destruction of all specimens. It was in this context that we decided to experiment with solid sectioning.

Simple sectioning of teeth by grinding or sawing tended to damage the fragile cementum layer, which is actually bone weakly bonded to the outside of dentin below the gum line (*4*). To overcome this problem, we encapsulated the teeth in plastic by pouring liquid epoxy over a tooth placed in a mounting cup. When the epoxy cured, the tooth was held firmly in a plastic envelope.

Two plastic preparations were used. One, a fast-setting epoxy (Buehler Epo-Kwick), generated considerable heat and tended to produce large bubbles, apparently filled with water vaporized from the tooth. The other plastic was a mixture of liquid and powder (Buehler Plastic Kit) which set in about 45 minutes to 1½ hours. The latter produced a satisfactorily though not perfectly tight envelope, and no bubbles were observed.

We tried a variety of mounting cups, including commercial capsules designed for mounting metallographic sections. Equally successful as mounting containers were plastic 35-mm film containers with the top in place and the bottom cut out.

The mounted tooth was removed from the capsule and sawed or ground on an industrial belt sander so that a longitudinal section of the tooth was exposed. This exposed section was then polished by hand on 600 alumina grit paper and examined under a binocular microscope with reflected light at a magnification of × 40 to × 150 power. We were often able to enhance the visual contrast by wetting the specimen with ethanol.

Sectioning of encapsulated teeth has produced analyzable sections from archeological contexts where decalcification has failed or has succeeded on only a small proportion of teeth. Initial experiments with teeth from the Turner Farm were largely successful. It appears that the individuals examined were killed during the winter and possibly early spring (Figs. 1 and 2). This pattern, if confirmed by future tests, supplements other seasonal data and raises the interesting possibility that the site was occupied during much of the year, especially during the late Archaic period. Initial success with specimens from the Turner Farm led us to test teeth from other North American sites (Fig. 2).

Although incremental layers as observed in solid sections may lack the high contrast of those from decalcified thin sections, they are usually analyzable if present. In some instances, where initial observations were inconclusive, repolishing produced clearer results (repolishing is essentially analogous to the preparation of multiple thin sections from decalcified teeth).

Thus, solid sectioning appears to give results roughly comparable to decalcification but with less risk of destruction. For the novice, however, the lowered contrast may make it more difficult to analyze the section relative to the case for decalcified and stained thin sections. Surprisingly, the times required for the preparation of solid and decalcified sections is roughly equal: about 15 minutes per tooth, disregarding unattended time of plastic hardening or decalcification. However, decalcification is a relatively delicate procedure requiring sophisticated equipment whereas grinding solid sections is a "low technology" approach which might even be attempted as a short-range analytical technique in field laboratories.

We caution that the periodicity and seasonal significance of incremental growth layers is clearly established for only a relatively small number of species, primarily those from temperate and arctic North America. Therefore, we urge caution in extrapolating patterns observed in modern teeth to unstudied species.

BRUCE J. BOURQUE, KENNETH MORRIS
Maine State Museum, Augusta 04330
ARTHUR SPIESS
Peabody Museum, Harvard University, Cambridge, Massachusetts 021388

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Images of Io's Sodium Cloud

Abstract. *The first direct images of Io's sodium cloud are reported and analyzed. The observed cloud extends for more than 10^5 kilometers along Io's orbit and is a somewhat "banana-shaped" partial toroid. More sodium atoms precede Io than follow it. A model based on the escape of sodium from a specific localized area on Io provides a reasonable fit to the observed intensity distribution whereas isotropic escape does not.*

Io, the innermost of Jupiter's Galilean satellites, has long been known for its unusual properties. Io has the highest reflectance of any object in the solar system and governs the bursts of decametric radiation from the jovian magnetosphere. Spectral reflectance data suggest that it has evaporite minerals or "salts" on its surface (*1*). In 1973 Brown discovered that sodium atomic line emissions were emanating from Io (*2*). The sodium is distributed throughout an immense volume about Io and fluoresces in its resonant D lines in proportion to the available sunlight (*3*). The source of the sodium is believed to be Io's surface material. Sodium could be released by the sputtering action of magnetospheric proton and ion bombardment, and much of it would have sufficient velocity to escape from the satellite (*4*). Neutral sodium atoms are removed from the cloud chiefly by electron impact ionization whereupon emission in the characteristic D lines is no longer possible (*5*).

In order to understand the processes governing the production and loss of sodium in the cloud, we must know the spatial distribution of sodium about Io. In this report we describe two images that we have obtained of Io's sodium cloud (Figs. 1 and 2) and report the first results of the study of these images. A more detailed analysis of these and other images will appear elsewhere (*6*). The two images were obtained with the coudé spectrograph at the 61-cm (24-inch) telescope at Table Mountain Observatory. Instead of the usual spectrograph entrance slit, we substituted a thin plate of glass upon which a small spot of aluminum was deposited. During an exposure the image of Io was guided near the center of this occulting element, thus excluding the solar continuum reflected by Io from the spectrograph. Atomic line emission from the surrounding cloud, however, was permitted to enter the spectrograph. This radiation was dispersed by the grating into distinct components corresponding to each of the sodium lines. At the focus of the spectrograph the "slit" or object plane was imaged, and two images corresponding to the D_1 and D_2 emission lines were seen. Since the portion of the cloud closest to Io was blocked by the occulting disk, the shadow of the disk is present in the cloud images. All data were recorded with a silicon imaging photometer system (SIPS) with a silicon intensifier tube (RCA 4804) (*7*). In our observations the spectral smearing of the image due to the finite width of the emission lines is comparable in amplitude to the uncertainties introduced into the images by astronomical "seeing." Thus the effect is not significant for the present data set.

The cloud images demonstrate that the sodium is distributed asymmetrically about Io. The sodium emission was most intense in the west at the time these data were taken; both images show considerably less sodium emission to the east and to the north and south. The cloud in Fig. 1 is seen to extend westward from Io some 50 arc seconds or about 1.9×10^5 km. This extension is less in Fig. 2 because of foreshortening resulting from a different viewing angle. These two images, considered together, indicate that the sodium extends along Io's orbit as suggested by Carlson *et al.* (*5*). The observed geometry is compatible with a partial toroid shaped somewhat like a banana. It is not consistent with the high velocity radial streaming model which

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