Methods

A Method for Differentiating Modern from Ancient Proboscidean Ivory in Worked Objects

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The visual identification of proboscidean ivory in worked objects is facilitated by a unique pattern of crossing lines which is readily apparent in transverse section. These lines appear as a thick band within the dentine covering from approximately thirty to one hundred percent of the dentinal area between the cementum and the central nerve cavity. They have been referred to as "curvilinear lozenges" (Owen 1856), "engine-turned decussat(ions)" (Penniman 1952), and "rhombic meshes" (Thornton 1980). A generally accepted term for this pattern is Schreger lines (Hanausek 1907). Measurable angles occur at the crossing of Schreger lines.

Two researchers, Penniman (1952) and Sanford (1973), observed that the Schreger line pattern seemed to form narrower angles in mammoth ivory than in modern elephant ivory. Pursuant to this observation, we examined 21 samples of modern elephant ivory (*Loxodonta africana* and *Elephus maximus*) and 19 samples of ancient mammoth and mastodont ivory (*Mammuthus primigenius, Mammuthus columbi, Mammuthus* unspecified, *Mammut* unspecified, *Gomphotherium simpsoni* and *Gomphotherium* unspecified) for Schreger angulation measurement.

Initial examination of our samples showed that Schreger angles appear in two forms. We have designated these forms as inside angles and outside angles (Figure 1). Inside angles are slightly concave and open to the inner (medial) area of the tusk. Outside angles are somewhat convex and open to the outer (lateral) area of the tusk.

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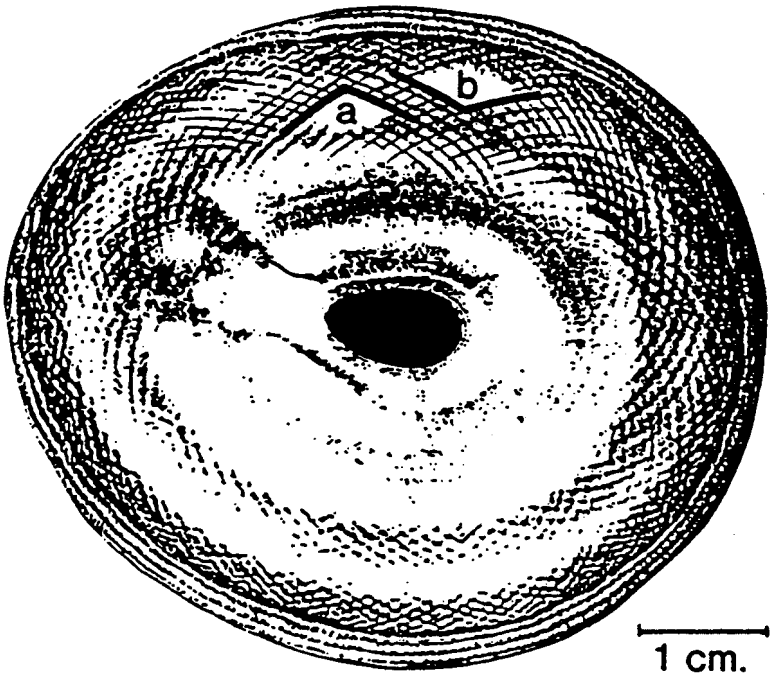

Figure 1. Enhanced photocopy of Schreger angles in a transverse section of African elephant (*Loxodonta africana*) tusk: a. inside angle b. outside angle.

Of two methods used to measure Schreger angles, the first method utilized photocopy technology to capture and enhance the Schreger angles. A blue xerographic transparency sheet was imposed between an ivory sample and the photocopy machine's glass copy plate. The machine was then set for a variable enlargement factor of up to 141%. The Schreger angles which appeared on the resulting photocopy of the ivory sample were marked with a pen or pencil and measured using a protractor. This method is preferable for angle measurement on flat objects. Photographic enlargement or digital image enhancement can be used in place of photocopy capture and enhancement.

The second method involved the production of an angle template. A 6 by 21.5 cm piece of clear xerographic transparency sheet was inked with a series of thirteen 1 cm squares containing angles from 60° to 140°. The marked angles were in 5° increments in the mid-range and 10° increments in the low and high ranges. This template was overlaid on a photocopy of the ivory sample or directly on the sample itself. The observed Schreger angles were "fitted" to one of the template angles for approximate angle measurements. This method can be performed on flat objects or on moderately curved surfaces. Digital image enhancement can be particularly useful with curved surfaces.

We measured five inside and five outside angles in each of our modern ivory samples and two to five inside/outside angle sets in our ancient ivory samples. Modern elephant inside Schreger angles ranged from 96° to 149° with a mean

angle of 115°. Modern elephant outside Schreger angles ranged from 105° to 156° with a mean angle of 130°. The ancient ivory samples showed significantly lower mean Schreger angles. The inside angles in our ancient samples ranged from 40° to 95° with a mean of 73°. The outside angles from these samples ranged from 39° to 100° with a mean of 76°. The inside and outside and Schreger angles vary less in ancient than in modern proboscidean ivory.

An area of angle overlap exists in the lower end of the modern elephant inside angle range and the upper end of the ancient inner/outer proboscidean angle ranges. This area of overlap can be observed in modern ivory in the section of the dentine with a manifest Schreger lines which is closest to the central nerve cavity. Misidentification based upon angle measurement in this overlap zone can often be avoided by measuring multiple angles over as wide an area as possible.

While visual identification of proboscidean ivory using Schreger line recognition is a relatively simple routine matter, the non-destructive differentiation of modern and ancient ivories, particularly in worked objects, is not. However, we believe that we have observed and recorded a statistically reliable and reproducible method for distinguishing between modern and ancient proboscidean ivory. A comprehensive report on the results of our ivory analyses is currently in preparation.

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