Journal of Archaeological Science 38 (2011) 2908–2913

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Earliest art in the Americas: incised image of a proboscidean on a mineralized extinct animal bone from Vero Beach, Florida

Barbara A. Purdy [a], Kevin S. Jones [b], John J. Mecholsky [b], Gerald Bourne [b], Richard C. Hulbert Jr. [c], Bruce J. MacFadden [c], Krista L. Church [d], Michael W. Warren [a], Thomas F. Jorstad [e], Dennis J. Stanford [f], Melvin J. Wachowiak [g], Robert J. Speakman [g,*]

[a] Department of Anthropology, University of Florida, Gainesville, FL 32611, USA
[b] Department of Materials Science and Engineering, University of Florida, Gainesville, FL 32611, USA
[c] Florida Museum of Natural History, University of Florida, Gainesville, FL 32611, USA
[d] Department of Anthropology, University of Texas, Austin, TX 78712, USA
[e] Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560, USA
[f] Department of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560, USA
[g] Museum Conservation Institute, Smithsonian Institution, Museum Support Center, 4210 Silver Hill Rd., Suitland, MD 20746, USA

ARTICLE INFO

Article history:
Received 8 April 2011
Received in revised form
25 May 2011
Accepted 26 May 2011

Keywords:
Old Vero site
Incised art
Terminal Pleistocene
Mammoth
Mastodon

ABSTRACT

A fragmented fossil bone incised with the figure of a proboscidean was recently found at Vero Beach, Florida near the location where Late Pleistocene fauna and human bones were recovered from 1913 to 1916. This engraving may represent the oldest and only existing example of Terminal Pleistocene art depicting a proboscidean in the Americas. Because of the uniqueness, rarity, and potential antiquity of this specimen, caution demanded that a variety of tests be used in an attempt to verify its authenticity. The mineralized bone was identified as mammoth, mastodon, or giant sloth. Rare earth element analysis was consistent with the fossil bone being ancient and originating at or near the Old Vero site (8-IR-9). Forensic analysis suggests the markings on the bone are not recent. Optical microscopy results show no discontinuity in coloration between the carved grooves and the surrounding material indicating that both surfaces aged simultaneously. Scanning electron microscopy (SEM) revealed that the edges of the inscription are worn and show no signs of being incised recently or that the grooves were made with metal tools. In addition, the backscattered SEM images suggest there is no discontinuity in the distribution of light and heavy elements between the scribed region and the surrounding bone indicating that both surfaces aged in the same environment. This is very different from an intentional mark made on the bone for comparison. Energy dispersive x-ray spectroscopy (EDXS) shows that the surface contains significant amounts of calcium, phosphorus, oxygen, and carbon typical of a mineralized bone surface. Examination of a cast and mold of the incised bone by Reflectance Transformation Imaging (RTI) also provided no evidence that the engraving was made recently. All of these results are consistent with the mammoth engraving being authentic.

Published by Elsevier Ltd.

1. Introduction

The dorsal surface of a fragmented fossil bone recovered from Vero Beach, Florida contains an engraved image of a proboscidean (Fig. 1). Never before in the Western Hemisphere has there been found and validated a bone from an extinct faunal species incised with a recognizable image of a proboscidean.[1] The shortened, high-domed skull and longer forelimbs than hind limbs are consistent with the image being a mammoth (Lister and Bahn, 1994). If genuine, this rare and spectacular specimen provides evidence that people living in the Americas during the Terminal Pleistocene created artistic images of the animals they hunted. The incising would have to be at least 13,000 years old as this is the date for the last appearance of these animals in eastern North America (Faith and Surovell, 2009; Grayson and Meltzer, 2003; Steadman et al., 2005), and more recent Precolumbian people would not have seen a mammoth or mastodon to draw.

The image of the proboscidean is not readily apparent and could easily be overlooked; in fact, it was overlooked at first. The bone was collected by avocational fossil hunter, James Kennedy, from a location in northern Vero Beach sometime in 2006 or 2007.

* Corresponding author. Tel.: +1 301 238 1242; fax: +1 301 238 3709.
E-mail address: speakmanj@si.edu (R.J. Speakman).

[1] In 1959, Juan Armenta Camacho discovered a mastodon pelvis at Valsequillo, Mexico engraved with multiple Ice Age animals, including a mammoth (Scott, 1999, Fig. 1.2). The object has since disappeared (Meltzer, 2009:106). See Hardaker (2007) for an in depth description of the artifact and the controversy surrounding dating issues of sites in the area where it was found.

0305-4403/$ – see front matter Published by Elsevier Ltd.
doi:10.1016/j.jas.2011.05.022

Fig. 1. a. Photograph of the fragmented fossil bone; 1b. close-up of the engraving. Photo credit: Chip Clark, Smithsonian National Museum of Natural History.

In February 2009, Kennedy discovered the engraving of the proboscidean while cleaning the bone which had been stored at his home along with others he had found. Recognizing the potential importance of the bone, Kennedy contacted several of the authors of this paper who in turn initiated the research described herein. The fragment of bone is 40.1 cm (ca. 15.75 inches) long, 10.2 cm (4 inches) wide (width is variable), and 4.0 cm (ca. 1.6 inches) thick (thickness is variable). The length of the design is ca. 7.5 cm (3 inches) from the top of the head to the tip of the tail; the height of the design is ca. 4.5 cm (1.75 inches) from the top of the head to the bottom of the right foreleg. The fossil bone is a fragment from the shaft of a long bone of a large mammal (based on thickness of the cortical bone layer and the degree of curvature which indicates the original circumference of the bone), most likely either a mammoth (*Mammuthus*) or mastodon (*Mammut*), or less likely a giant sloth (*Eremotherium*). A precise identification is not possible because of its fragmented condition and lack of diagnostic morphologic features. It is certainly derived from a much larger land mammal than any known to have been alive in Florida during the Holocene interval (e.g., bear, bison, deer), and the thickness of the cortical bone precludes a cetacean origin. Because the bone is mineralized, it is improbable that it can be identified by DNA analysis or dated by ^{14}C. This is usually the case for Late Pleistocene fossils from Florida (e.g., Hulbert et al., 2009).

2. Background

For more than one hundred years, art objects, purportedly fashioned by aboriginal Americans, have been forged. Meltzer for example, summarizes the fraud of the Holly Oak shell pendant engraved with the image of a mammoth (Meltzer and Sturtevant, 1983; Meltzer, 2009). First announced in 1889, the image was suspected immediately as a copy of a specimen described by Lartet (1865) from the La Madeleine site in France, but the hoax was not exposed in print until the 1980s (Griffin et al., 1988).

Hundreds of depictions of proboscideans are known today from European caves and portable bone art (Delporte, 1990; Guthrie, 2005), but none from America (Meltzer, 2009:76), until the recent find from Vero Beach, Florida. Since 1913, people have collected fossils of Late Pleistocene vertebrate fauna from a streambed, Van Valkenburg Creek, intersected by the construction of the Vero canal that extends several miles westward from the Indian River on the eastern coast of Florida (Sellards, 1916, 1918; Sellards et al., 1917; Weigel, 1962). The fauna include many of the typical members of the now extinct Late Pleistocene North American megafauna, such as mammoth, mastodon, ground sloth (three species), tapir, horse, llama, dire wolf, and sabertooth cat (*Smilodon*). Large numbers of these fossils are stored or exhibited at the Florida Museum of Natural History (FLMNH) in Gainesville and the Smithsonian's National Museum of Natural History; others are

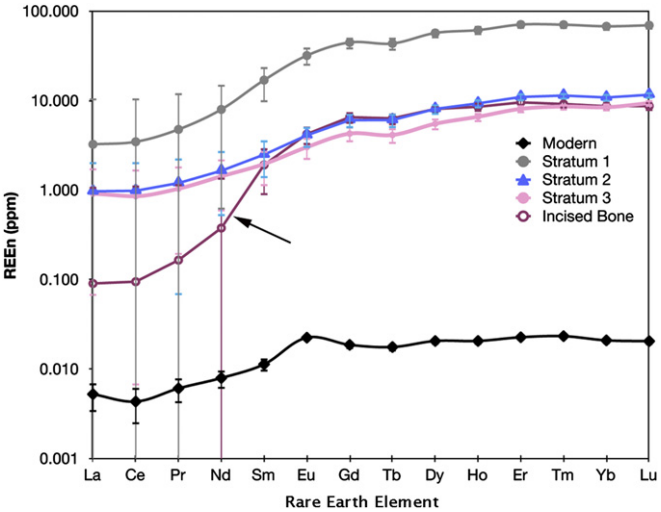

Fig. 2. Rare earth element (REE) concentrations of the incised bone compared to the average values by stratum at the Old Vero Site (8-IR-9).

in private collections, such as the incised bone discussed herein. In 1915 and 1916, human skeletal remains were found in the same vicinity of the Vero canal, engendering disagreement about their contemporaneity with the fossil animals that has never been resolved. Many of the human bones also reside at the FLMNH (Sellards, 1916; Purdy, 2008). Impending construction in the area of the original finds at the Vero site and the recent discovery of the incised bone have re-opened long-unanswered questions about human occupation on the east coast of Florida during the Terminal Pleistocene.

There is a significant scientific literature addressing the gross and microscopic characteristics of cut marks in bone. These studies have utilized both experimental and observational approaches to attempt to differentiate human agency from other taphonomic agents, including carnivore and scavenger activity, trampling, weathering and thermal damage (Gibert and Jimenez, 1991; Fisher, 1984; Shipman and Rose, 1983a,b). The aforementioned research has made great strides in establishing criteria for interpreting cut marks in bone, with special emphasis on the use of scanning electron microscopy (SEM) as the best diagnostic tool. A second body of literature exists within the subfield of forensic anthropology. These studies focus on the immediate postmortem interval and serve to provide insight into the differentiation of perimortem trauma from postmortem taphonomic changes to human bone. This most often is accomplished by examination of the margins, floor, and kerf wall under light microscopy. In this case, the question is not with cut mark mimics produced by non-human agents, since the image of the proboscidean is evidence enough that a human produced the engraving. The only consideration here is the timing of the engraving-is it ancient or was it recently incised to mimic an example of prehistoric art?

3. Methods

Several different analytical methods were employed to examine the incisions on the bone. To help verify that the bone had come from the Vero area of Florida, rare earth element analysis (REE) was conducted on powdered bone samples using a Thermo Finnigan ELEMENT2 inductively coupled plasma-mass spectrometer in the University of Florida Department of Geological Sciences (for methods see MacFadden et al., 2007). Optical microscopy was undertaken using an Olympus microscope with an Olympus CCD camera for image capture. A Tescan Vega II XMU variable pressure SEM at an accelerating voltage of 10 kV was used for both secondary imaging and backscattered imaging. A small sample from the surface of the bone was removed and energy dispersive X-ray spectroscopy (EDS) was performed on a JEOL 6400 SEM. Finally, a cast and mold of the specimen were examined by Reflectance Transformation Imaging (RTI) and microscopy at the Smithsonian Institution in Washington, D.C.

Reflectance Transformation Imaging (RTI) (Dellepiane et al., 2006; Earl et al., 2010; Mudge et al., 2006, 2010) is a newer imaging technique in which multiple digital images (ca. 40–50 images) of a subject, in a fixed position, are collected from a fixed camera position. During the acquisition of the images, the light source is moved from point to point to create a hemisphere of light. The images are then stored as Digital Negatives (DNGs) on the hard drive and formatted as jpegs for data processing using the open source software, RTI Builder, which creates a single Polynomial Texture Map (PTM) file. The software processes the multiple images into a single file that derives all possible light positions within the virtual hemisphere of light. The final image looks like a 2D photograph, but is actually the documentation of the subject's surface interaction with the light positions, at the individual pixel level. By moving a mouse (or other pointing device), the viewer can control the light direction, zoom in and out, and select data enhancement options that increase sharpness and contrast.

4. Results

Rare earth elements (REE) of extinct mammalian bones from the Old Vero site (8-IR-9) in the FLMNH collection were analyzed in conjunction with a sample from the incised bone to determine (1) if the incised bone was a fossil (true fossils have REE concentrations two or more orders of magnitude greater than modern bone (Trueman et al., 2004)), and (2) if the bone actually came from Vero

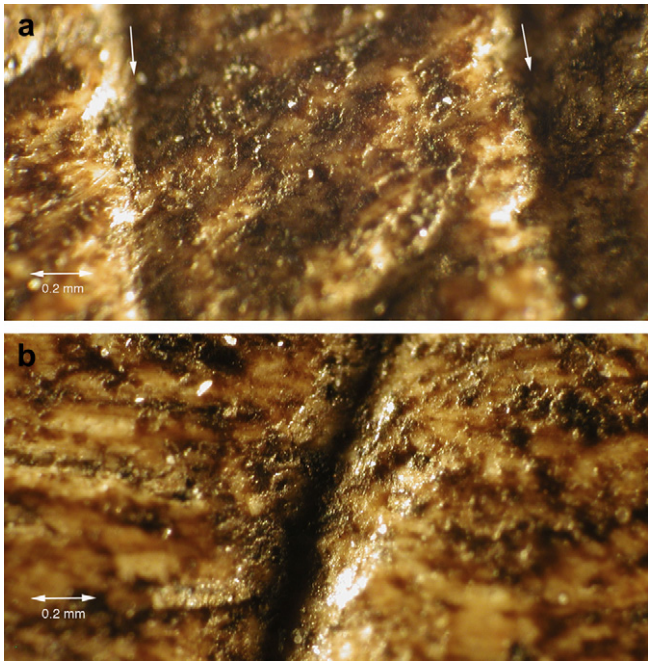

Fig. 3. a. Two inscribed lines (trunk of proboscidean) showing that the coloration is the same inside the lines as well as on the surface; 3b. inscribed line on incised bone (upper front leg) showing the smooth edges of the incised line.

Beach deposits based on similarities in REE signatures (MacFadden et al., 2007). Samples from different strata at the site were compared to the incised bone: stratum 1 (bottom) is a thick deposit of marine shell and sand called the Anastasia Formation; stratum 2 is the Melbourne Formation where most of the extinct fauna occur; stratum 3 is the overlying Van Valkenburg Formation. An erosional zone with some mixing of deposits between strata 2 and 3 is called the Melbourne-Van Valkenburg. A majority of the fossils used for the REE analysis came from this contact zone. Samples of modern bone recovered from the surface at the site were analyzed along with the extinct fauna. The results of the REE analysis are shown in Fig. 2. The elevated concentrations of REE indicate that the bone is fossil, not modern. The deviation of the light REE (LREE) relative to most of the Vero specimens might suggest a different geographic and/or diagenetic environment. However, LREE tend to be more variable within a population than medium or heavy REE; at least two of the analyzed samples have similar LREE distributions. It is clear from Fig. 2 that the heavier REE signature between the incised bone and samples from strata 2/3 of the site are a very close match and are significantly different from a modern sample. These results support the premise that the bone is ancient and came from the Vero region of Florida.

The incised bone was examined using several visual approaches. First, it was inspected using an optical microscope. Fig. 3a shows two incised groves from the trunk of the proboscidean engraving. Fig. 3b shows another optical microscope image of the upper part of the leg. Both images reveal that the damage that occurs to incisions as part of the taphonomic alteration of a bone indicates signs of wear and erosion. The margins of the cut mark on the bone are smoothed and rounded and the floor of the cut mark shows the same coloration and environmental inclusions as the rest of the bone. It is known that as bone becomes more and more eroded (e.g., soil, wind, water, or a combination of these), the defect (e.g., cut mark) becomes wider and the margins become more rounded. The marks on this specimen display the latter characteristics. In addition, the cut marks lack any subtle differences in color and texture within the margins of the engraving in comparison with the remainder of the bone that would occur if the incision were done recently.

SEM imaging of the incision also was conducted. A section of the lower tusk was imaged in secondary electron mode and is depicted in Fig. 4a. The arrow indicates the location of the incised line. Fig. 4b shows the backscattered image of the exact same region as 4a. The arrow in each figure can be used as a reference point between the two figures. In the secondary electron image in 4a, the groove readily is apparent and there is no sign of a debris field along the edge of the scribe. In the backscattered image 4b, the incised line can no longer be seen. This indicates the relative masses of the elements on the surface show no discontinuity; that is, the composition in the bottom of the groove is consistent with the surrounding matrix. It appears that the mineralization occurred across the indentations caused by the scribing. This supports the probability that the indentations occurred before the bone was mineralized and the bottom of the incised line and the surrounding materials aged at the same time in the same environment.

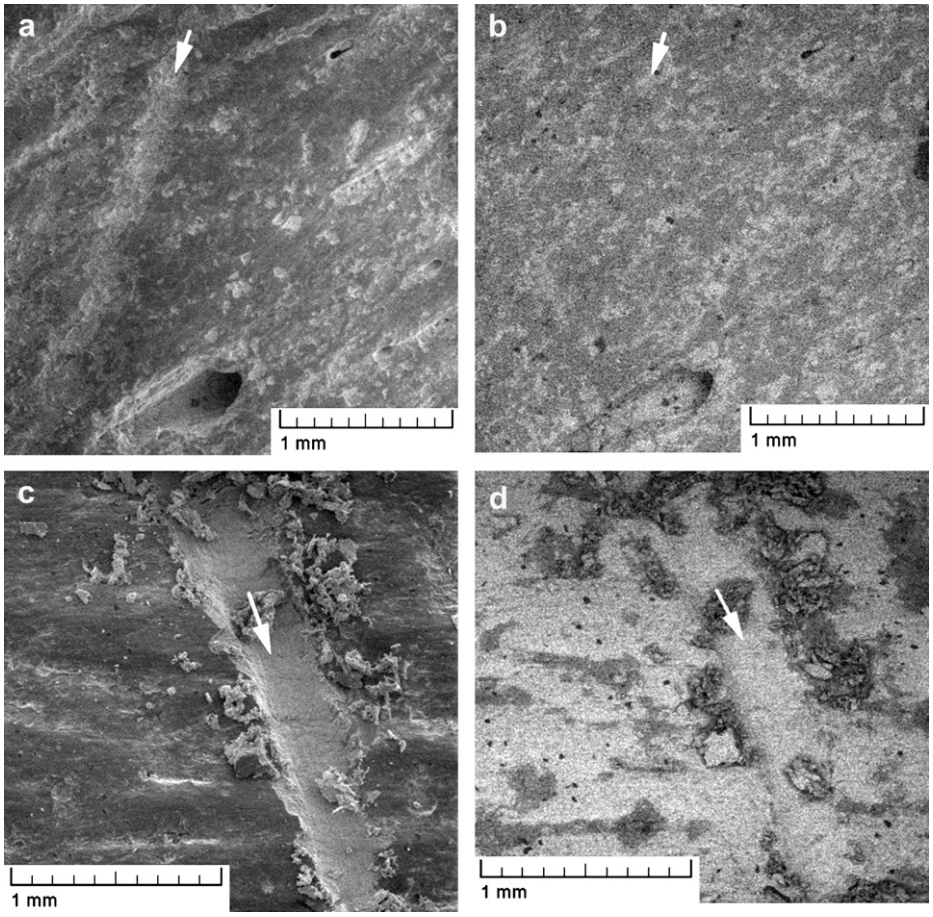

Fig. 4. a. Secondary electron SEM image of tusk region of incised image; 4b. backscattered electron SEM image of identical region as Fig. 4a showing identical backscattered contrast inside the incision as surrounding material; 4c. secondary image of intentional scratch made by authors on the surface showing debris field and rough edges; 4d. backscattered image of exact same region as 4c showing a clear difference in the backscattered contrast inside the scratch compared to the surrounding material (note lack of any dark contrast inside scratch).

In an adjacent region, the surface of the bone was intentionally incised using a razor blade. This mark was subsequently examined in both secondary electron (Fig. 4c) and backscattered electron mode (Fig. 4d). In contrast to Fig. 4a, the secondary electron image for the recent scratch (Fig. 4c) shows an extensive debris field and a jagged edge. Finally, in contrast to Fig. 4b, the backscattered image in 4d shows a discontinuity in the average atomic number of the elements on the surface surrounding the grove and the region at the bottom of the groove. The light and dark patterns in the surrounding material (indicative of minor elemental variations) are not reproduced in the bottom of the groove (no dark and light contrast, only light contrast).

D'Errico et al. (1998) used similar imaging methods to study the Sherborne bone-a purported example of Paleolithic art containing the engraving of a horse's head on bone. The object was *discovered* by schoolchildren in Sherborne, England, in the early 1900's and subsequently proved to be fake on the basis of AMS dating which showed the bone to be about 600 years old (Stringer et al., 1995) and through microscopic analysis. Of particular relevance here is that D'Errico et al. (1998) used the microscopy and backscattered electron imaging to demonstrate that the scribe, in that case, produced a debris field inside the inscription as well as a clear discontinuity between the incision and the surrounding bone. The authors argued that the debris field and discontinuity demonstrated that the bone was engraved after burial, rather than reburial after engraving. In our study, the discontinuities and debris fields were not observed.

To eliminate the possibility that someone had inscribed the surface and then coated the surface with a polymer to make it look the same inside and outside the carved area, energy dispersive x-ray spectroscopy (EDS) analysis of the surface showed the elemental composition of the surface was 21% Ca, 10% P, 56% O, and 13% C. All values are atomic %. This is consistent with mineralized bone and no presence of a polymer coating was observed. A specimen from the FLMNH collections that had been in storage for decades was analyzed for comparison; the results are shown in Fig. 5. It is likewise important to point out that the SEM EDS analysis identified no traces of metal that would be indicative of the use of metal tools to make the incisions.

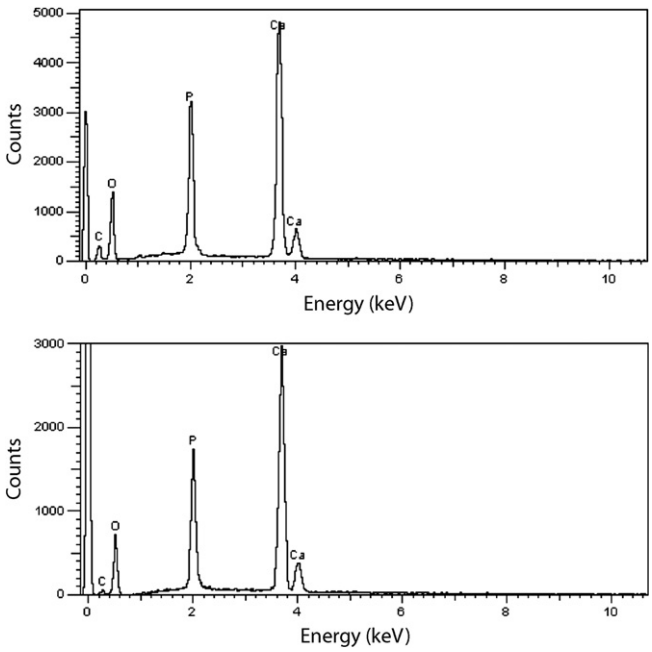

Fig. 5. EDS spectra confirming that no polymer was use to coat the surface of the incised bone. Top: Engraved bone from Vero; Bottom: comparison proboscidean bone from Vero.

As a final imaging approach, Reflectance Transformation Imaging (RTI) was employed on a cast and mold of the bone. The results of the RTI supports the microscopy work described above, that is, there is no evidence that the engraving was made recently. Interestingly, the RTI reveals the presence of a diamond pattern/cross hatched lines that frame the mammoth engraving-particularly on the left side. These lines extend up to the edges of the bone, but do not extend onto the rounded and weathered edge (Fig. 6). This suggests that the engraving occurred before the bone broke and/or weathered.

5. Discussion

There exists the possibility that the incised bone is a forgery since it was found by an avocational fossil hunter. In addition, the long-term taphonomic effects of soil, water and weather on the cut marks are unknown. Finally, it is always possible that a forgery was done and then altered by artificial processes that impacted the surficial character of the bone. However, at this point all scientific evidence is consistent with the incisions mineralizing simultaneously with the surrounding bone surface.

In 1916, Dr. E.H. Sellards, the State Geologist of Florida, announced the discovery of human skeletal remains in apparent association with numerous species of extinct late Ice Age animals from the main canal at Vero Beach, Florida. His claim has been disputed for 95 years, even though it is now well known that people were in the Western Hemisphere and hunted those animals during the Terminal Pleistocene (e.g., Anderson, 2005; Johnson, 2005; Meltzer, 2009; Purdy, 2008). The results of the testing done in this work of the recently discovered fragmented fossil bone bearing the unmistakable engraving of an ancient proboscidean recovered from the same area of the canal as the human and animal fossils reported in 1916 appear to support E.H. Sellards argument that the Vero site provided evidence of a Pleistocene human presence in North America.

Of broader significance is the similarity of the engraving on the Vero bone to Upper Paleolithic art styles and subjects of the Old World. The issue of when, how, and from where people first entered the Western Hemisphere and dispersed has long been debated and is not likely to be resolved anytime soon. Nonetheless, for many years similarities have been noted between Paleoindian chipped stone tool assemblages and certain ivory and bone tools with nearly

Fig. 6. RTI screenshot of a cast of the bone showing the cross hatched lines that occur to the left of the incised proboscidean image.

identical specimens in Western and Eastern Europe and beyond (e.g., Stanford and Bradley, 2004). The similarity of the Vero engraving with Upper Paleolithic European art begs the question of whether this similarity is simply due to coincidence or if there exists a more direct Ice Age connection between North America and Europe as Stanford and Bradley (2004) have argued. The debate over this connection will not likely be decided anytime soon. But, hopefully, in the near future modern scientific investigation will occur at the Vero Beach site that will provide additional data to address this important question and others. Additionally, the development of a method to date mineralized bone is needed and, if successful, would furnish a valuable means to solve persisting problems about America's ancient inhabitants.

6. Conclusion

A partial bone of a large mammal (probably mammoth, mastodon or giant sloth) has been discovered. The bone contains an incised, accurate drawing of a proboscidean, most likely a mammoth, on the dorsal surface. Rare earth element analysis is consistent with the bone being a fossil from the Vero region of Florida. Optical and electron microscopy results are consistent with the engraving being old, i.e., the mineralization of the bottom of the inscriptions matches the surrounding bone. EDS results are consistent with mineralized bone, and REE signatures are comparable to vouchered samples from the Vero site. Reflectance Transformation Imaging (RTI) corroborated evidence from other analyses. Apparently, the drawing was made prior to the extinction of the mammoth, based on anatomical details, such as the relative sizes of the tusks and trunk, the high-domed head, and the long forelimbs. This bone likely represents one of the first verified Paleoindian representations of a proboscidean in the Western hemisphere.

Acknowledgments

The authors would like to acknowledge the Major Analytical Instrumentation Center in the Department of Materials Science and Engineering and the Tribology Laboratory under the direction of Professor W.G. Sawyer at the University of Florida. E. Keats Webb is thanked for assistance with the RTI imaging at the Smithsonian Museum Conservation Institute. Jane Walsh and Pete Kroehler at the National Museum of Natural History are acknowledged for their assistance with making the cast of the bone. In addition, we would like to acknowledge the valuable comments received from numerous archaeologists and paleontologists throughout the United States and elsewhere. Finally, we extend our sincere appreciation and gratitude to Mr. James Kennedy, the discoverer of the bone, for bringing it to the attention of the authors and for permitting the analyses that are described herein.

References

Anderson, D.G., 2005. Pleistocene human occupation of the southeastern United States: research directions for the early 21st century. In: Bonnichsen, R., Lepper, B.T., Stanford, D.J., Waters, M.R. (Eds.), Paleoamerican Origins: Beyond Clovis. Texas A&M University Press, College Station, pp. 29–42.

Dellepiane, M., Corsini, M., Callieri, M., Scopigno, R., 2006. High quality ptm acquisition: reflection transformation imaging for large objects. In: Ioannides, M., Arnold, D., Niccolucci, F., Mania, K. (Eds.), Proceedings of 7th International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage (VAST2006). The Eurographics Association, pp. 179–186.

D'Errico, F., Williams, C.T., Stringer, C.B., 1998. AMS dating and microscopic analysis of the Sherborne bone. Journal of Archaeological Science 25, 777–787.

Delporte, H., 1990. L'image des animaux dans l'art préshistorique. Picard, Paris.

Earl, G., Beale, G., Martinez, K., Pagi, H., 2010. Polynomial texture mapping and related imaging technologies for the recording, analysis and presentation of archaeological materials. In: International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, pp. 218–223, vol. XXXVIII, Part 5 Commission V Symposium, Newcastle Upon Tyne, UK.

Faith, J.T., Surovell, T.A., 2009. Synchronous extinction of North America's Pleistocene mammals. Proceedings of the National Academy of Sciences of the United States of America 106, 20641–20645.

Fisher, D.C., 1984. Taphonomic analysis of late Pleistocene mastodon occurrences: evidence of butchery by North American Paleo-Indians. Paleobiology 10, 338–357.

Gibert, J., Jimenez, C., 1991. Investigations into cut-marks on fossil bones of Lower Pleistocene age from Venta Micena (Orce, Granada, Spain). Human Evolution 6, 117–128.

Griffin, J.B., Meltzer, D.J., Smith, B.D., Sturtevant, W.C., 1988. A mammoth fraud in science. American Antiquity 53, 578–582.

Grayson, D.K., Meltzer, D.J., 2003. A requiem for North American overkill. Journal of Archaeological Science 30, 585–593.

Guthrie, R.D., 2005. The Nature of Paleolithic Art. The University of Chicago Press.

Hardaker, C., 2007. The First American: The Suppressed Story of the People Who Discovered the New World. New Page Books, Franklin Lakes.

Hulbert, R.C., Morgan, G.S., Kerner, A., 2009. Collared peccary (Mammalia, Artiodactyla, Tayassuidae, Pecari) from the late Pleistocene of Florida. In: AlbrightIII, L.B. (Ed.), Papers on Geology, Vertebrate Paleontology, and Biostratigraphy in Honor of Michael O. Woodburne, vol. 65. Museum of Northern Arizona Bulletin, Flagstaff, Arizona, pp. 531–544.

Johnson, E., 2005. Late-Wisconsinan mammoth procurement in the North American grasslands. In: Bonnichsen, R., Lepper, B.T., Stanford, D.J., Waters, M.R. (Eds.), Paleoamerican Origins: Beyond Clovis. Texas A&M University Press, College Station, pp. 161–182.

Lartet, E., 1865. Une lame d'Ivoire fossile trouvée dans un gisement ossifère du Périgord, et portant des incisions qui paraissent constituer la reproduction d'un eléphant à longue crinère. Compte Rendu des Séances de l'Académie des Sciences 61, 309–311.

Lister, A., Bahn, P., 1994. Mammoths. MacMillan, New York.

MacFadden, B.J., Labs-Hochstein, J., Hulbert Jr., R.C., Baskin, J.A., 2007. Revised age of the late Neogene terror bird (Titanis) in North America during the great American Interchange. Geology 35, 123–126.

Meltzer, D.J., 2009. First Peoples in a New World. University of California Press, Berkeley.

Meltzer, D.J., Sturtevant, W.C., 1983. The Holly Oak shell game: an historic archaeological fraud. Anthropological Papers No. 72. In: Dunnell, R.C., Grayson, D.K. (Eds.), Lulu Linear Punctated: Essays in Honor of George Irving Quimby. Museum of Anthropology, University of Michigan, pp. 325–352.

Mudge, M., Malzbender, T., Schroer, C., Lum, M., 2006. New reflection transformation imaging methods for rock art and multiple-viewpoint display. In: Ioannides, M., Arnold, D., Niccolucci, F., Mania, K. (Eds.), Proceedings of 7th International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage (VAST2006). The Europgraphics Association, pp. 195–202.

Mudge, M., Schroer, C., Earl, G., Martinez, K., Pagi, H., Toler-Franklin, C., Rusinkiewicz, S., Palma, G., Wachowiak, M., Ashley, M., Matthews, N., Noble, T., Dellepiane, M., 2010. Principles and practices of robust, photography-based digital imaging techniques for museums. In: Artusi, A., Joly-Parvex, M., Lucet, G., Ribes, A., Pitzalis, D. (Eds.), Proceedings of 11th International Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage (VAST2010). The Europgraphics Association, pp. 179–186.

Purdy, B.A., 2008. Florida's People during the Last Ice Age. University Press of Florida, Gainesville.

Scott, J.F., 1999. Latin American Art: Ancient to Modern. University Press of Florida, Gainesville.

Sellards, E.H., 1916. Human Remains and Associated Fossils from the Pleistocene of Florida, Florida Geological Survey, 8th Annual Report, pp. 123–160.

Sellards, E.H., 1918. The Skull of a Pleistocene Tapir Including Description of a New Species and a Note on the Associated Fauna and Flora, Florida Geological Survey, 10th Annual Report, pp. 57–70.

Sellards, E.H., Chamberlin, R.T., Vaughan, T.W., Hrdlicka, A., Hay, O.P., MacCurdy, G.G., 1917. Symposium on the age and relations of the fossil human remains found at Vero, Florida. Journal of Geology 25, 1–62.

Shipman, P., Rose, J.J., 1983a. Evidence of butchery and hominid activities at Torralba and Ambrona: an evaluation using microscopic techniques. Journal of Archaeological Science 10, 465–474.

Shipman, P., Rose, J.J., 1983b. Early hominid hunting, butchering, and carcass-processing behaviors: approaches to the fossil record. Journal of Anthropological Archaeology 2, 57–98.

Stanford, D., Bradley, B., 2004. The North Atlantic ice-edge corridor: a possible palaeolithic route to the new world. World Archaeology 36, 459–478.

Steadman, D.W., Martin, P.S., MacPhee, R.D.E., Jull, A.J.T., McDonald, H.G., Woods, C.A., Iturralde-Vinent, M.A., Hodgins, G.W.L., 2005. Asynchronous extinction of late quaternary sloths on continents and islands. Proceedings of the National Academy of Sciences of the United States of America 102, 11763–11768.

Stringer, C.B., d'Errico, F., Williams, C.T., Housley, R., Hedges, R., 1995. The solution to the Sherborne problem. Nature 378, 452.

Trueman, C.N.G., Behrensmeyer, A.K., Tuross, N., Weiner, S., 2004. Mineralogical and compositional changes in bones exposed on soil surfaces in Amboseli National Park, Kenya: diagenetic mechanisms and the role of sediment pore fluids. Journal of Archaeological Science 31, 721–739.

Weigel, R.D., 1962. Fossil vertebrates of Vero, Florida. Florida Geological Survey Special Publication 10, 1–59.