Reports

The Ginsberg Experiment: Modern and Prehistoric Evidence of a Bone-Flaking Technology

Abstract. *The discovery of butchered and modified bones of extinct Pleistocene fauna from Old Crow Flats, Yukon Territory, and the Dutton and Selby sites, Colorado, provides some of the earliest evidence for man in the New World. However, the significance of these discoveries rests entirely on the ability to determine whether these remains were modified by man. The results of experiments of elephant butchering, bone fracturing, and bone tool manufacturing support the hypothesis that these modified bones can be used to identify the presence of cultural activities.*

Research into the earliest human occupation of the Western Hemisphere has accelerated during the past decade with the discovery of sites which predate the widespread Clovis fluted-point tradition (*1–3*). Archeological evidence from dated localities now extends back in time to more than 50,000 years ago in the northern Yukon Territory (Old Crow collection) (*4, 5*), and later pre-Clovis occupations have been found in northeastern Colorado (Dutton and Selby collections) (*4, 5*). These localities have not produced direct evidence of a cohesive lithic technological tradition, but they do exhibit evidence of a well-developed technology in which bone was used as a raw material for tool production. Because little is known about this kind of bone technology modern elephant-bone breaking, bone toolmaking, and bone tool use experiments are reported here that can be used as analogs for the interpretation of early remains. These data are essential for developing criteria by which to distinguish the morphology of bones modified by man from those modified by natural agencies (*5–8*).

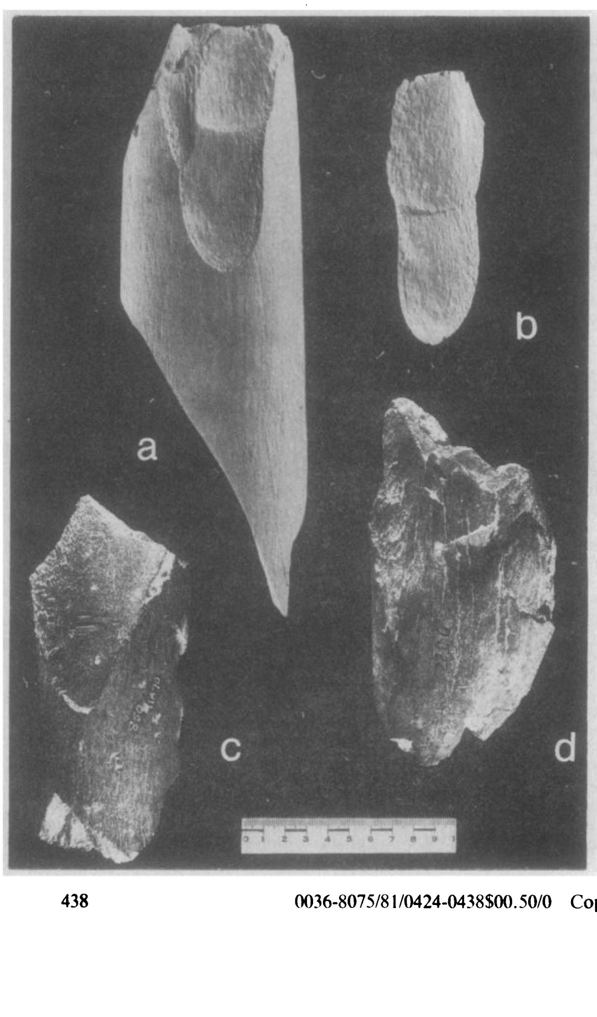

Fig. 1. Bone cores and flake. (a) Bone core from Ginsberg. (b) Bone flake that was struck from the core in (a). (c) Bone core from Old Crow Flats. (d) Bone core from the Dutton site.

The interpretation of the Dutton, Selby, and Old Crow collections rests in part on the hypothesis that bone can be flaked in much the same manner as stone. Experiments on bovid and equid bones have been invaluable in the interpretation of archeological assemblages (*4, 5*), but such thin-walled materials are clearly not comparable to the massive bones of mammoth and mastodon that occur in early New World sites (*1–3*). The closest comparable material from modern fauna is elephant bone. Although dry elephant bones have been broken experimentally, they are not nearly so tough and elastic as green bone (fresh bone) and are difficult to flake (*7*).

An opportunity to conduct bone-flaking experiments arose when Ginsberg, a 23-year old female African elephant who died in Boston's Franklin Park Zoo, was donated for the project. This experimental research was conducted in two phases. In March 1978 experiments were performed outdoors at the National Zoological Park Conservation Research Center (NZP-CRC), Front Royal, Virginia, and additional experiments were conducted in March 1979 at the National Museum of Man, Ottawa, in a laboratory setting. A variety of methods were used to document the experiments. Recording methods included 135-mm black-and-white and color slides, 16-mm color film, high-speed 16-mm black-and-white and color film (5000 frames per second), video tape, and acrylic casts of tool edges taken before and after specific experiments. A six-channel strip-chart recorder and an x-y-z plotter attached to the tools during cutting activities documented the tool angles, the duration of tool use, and the length and number of cuts. Bone breakage patterns and tools were modeled after the early Colorado and Yukon specimens. Replicas of large stone bifaces, interpreted to be part of the mammoth butchering tool kit from the Anzick Clovis burial site in Montana, were made and hafted for the experiment (*9*). Both stone and bone tools were used in comparative experiments involving

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skinning, meat stripping, periosteum removal, spiral fracture, marrow removal, and bone flaking. The detailed documentation of these experiments made it possible for us to assess behavioral processes responsible for the creation of morphological patterns observed in the archeological record and enhanced our ability to interpret fossil specimens.

Part of the Ginsberg experiment consisted of a comparison of the fracture of dried and fresh bones. An elephant femur from Kenya, which had been air-dried for more than 4 years, was impacted with a 5.9-kg cobble and shattered into fragments. By contrast, when green bone from Ginsberg was struck with a similar impactor, it was much more resistant to fracture. High-speed photographic documentation demonstrates that the green bone is highly elastic and flexes when impacted. Apparently, the green bone wall is depressed into the marrow cavity, and the compressed marrow absorbs much of the shock. Although both dry and green bones may exhibit spiral fractures of the kind often attributed to artificial breakage, the resulting fragments and their fracture surfaces do not share identical characteristics (*10*). Dry bone fragments have triangular to rectangular shapes, the fracture surfaces have a rough appearance, and the fracture fronts may cut through the epiphyseal ends, fracturing the epiphyses. Preexisting desiccation split-line cracks are thought to be important in controlling how dry bone fails (*4*, *5*). Green bone fracture patterns are quite variable. The support system used in holding bone elements is clearly a significant variable in determining how bone breakage will occur. Several independent fracture fronts usually expand outward from the point of impact, and their straight-line course causes diagonally oriented fronts to travel in spirals around the cylindrical shaft of a long bone. These fracture fronts do not cut through the articular ends of the bone since they are absorbed or deflected by the cancellous tissue in the epiphyses. Green bone fracture surfaces are usually quite smooth, and they often form acute and obtuse angles not only with the long axis of the bone but also with its outer surface. These angles are responsible for the sharp and durable edges produced on green bone fragments. A circular depressed area on the bone surface results from the blow delivered by the impactor. Crushed bone, bone cones, or bone flakes resulting from the blow collapse into the medullary cavity, leaving negative scars on the bone wall at the point of impact. These attributes are crucial in evaluating the fracture patterns seen on fossil specimens.

Once green bone has been fractured, fragments may be selected for tool production as is suggested by the mammoth bone cores and flakes from the Yukon and Colorado. Experimentation has shown that bone cores are relatively simple to produce by techniques commonly associated with lithic technology. For the removal of bone flakes, it is important to establish an acute angle between the striking platform and the dorsal face of the core. This steep angle prevents the impactor from slipping off the top of the core when the impact leading to flake removal occurs. An appropriate platform angle may be obtained by removing small flakes to prepare a striking platform. This process results in a negative hinge scar on the core platform as the fracture front is deflected by the longitudinally oriented collagen fibers. In another platform preparation technique, the platform surface is smashed with the impactor until a suitable acute-angle platform is created. Once a platform is prepared, one or several bone flakes may be detached from a core; these flakes parallel the alignment of collagen fibers oriented along the longitudinal axis of the element. As the platform becomes worn out from flake removal, it can be rejuvenated through the use of the technique mentioned above.

Not only are bone flakes simple to produce, but they are also effective butchering tools. The Ginsberg butchering experiments have shown that bone flakes are inadequate for cutting through tough elephant hide; however, they are quite satisfactory for slicing through either warm or frozen flesh. They are not particularly effective for cutting through thick myelin sheaths that surround muscles. Bone cutting implements worked best on frozen flesh, as thin membrane tissue from warm meat tends to adhere to the edge of the tool. Because bone flakes have thin elastic edges, they are very difficult to sharpen by percussion flaking techniques, and it is likely that bone flakes were discarded once the edges became dull.

The Ginsberg experiments provide useful analogs for interpreting the Pleistocene fossils found at the Selby and Dutton sites and the Old Crow collecting localities. The experiments have shown that techniques associated with lithic technology can be applied to green elephant bone for the production of tools and the reduction of bone cores by percussion flaking techniques. Many of our specimens appear to replicate precisely some of the modified Pleistocene fossils in our collections (Fig. 1).

Bone implements were widely used by prehistoric hunters living in grassland environments. These tools were commonly used for butchering bison at communal kill sites (*11*). This technological pattern may have great antiquity and may have been used for the exploitation of such extinct herd herbivores as camel (*12*), horse, bison, and mammoth (*13*). The adaptive advantage of bone tools is that they be made rapidly at the butchering station from the bones of the animal undergoing processing by the same principles that are used for working stone. Once the butchering operation is complete, the bone artifacts can be abandoned. Mobility would therefore be enhanced as the aboriginal hunters would not have to transport entire butchering tool kits to another kill site. The Ginsberg experiments have enhanced our abilities to recognize attributes diagnostic of artificially modified bones which can be used to identify the presence of man in the fossil record.

DENNIS STANFORD
*Smithsonian Institution,
Washington, D.C. 20560*

ROBSON BONNICHSEN
*University of Maine,
Orono 04473*

RICHARD E. MORLAN
*National Museum of Man,
Ottawa, Ontario, Canada K1A 0M8*

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First Radioisotope (Potassium-Argon) Age of Marine Neogene Rionegro Beds in Northeastern Patagonia, Argentina

Abstract. *An average age of 9.41 million years was obtained from radioisotope (potassium-argon) age determinations of three glass concentrates of a tuff from the upper part of the marine Rionegrense at Punta Cracker in Golfo Nuevo, Argentina. This age correlates with the Tortonian marine stage of Europe and the Chasicoan Land Mammal Age of South America.*

Ameghino (*1*) proposed the first classification of the marine Neogene of Argentina. He (*1*) recognized two major subdivisions, the Entrerriense (~ Mio-Pliocene) and the Rionegrense (~ Pliocene) (*2*). Beds of these ages crop out discontinuously over a broad area of northeastern Argentina from the Paraná basin (61°W, 32°S) south to the vicinity of Península Valdés (Fig. 1). Eustatic sea-level changes and gentle warping of this part of Argentina during the late Cenozoic have resulted in a number of transgressive cycles. The discontinuous nature of the outcrops and the similarity in the lithology of these deposits make correlations difficult. As a result, the age and stratigraphic succession of these beds is disputed (*3, 4*). Earlier age assignments of these beds were based on either comparisons of the molluscan faunas with coeval European faunas (*5*) or by the use of Lyellian percentages (*6*). This has led to age assignments ranging from Oligocene to Pleistocene (*1, 3, 4, 6, 7*).

Although rocks referrable to these stages are widespread throughout northern Chubut and Buenos Aires provinces, the most complete sequence is exposed along the sea cliffs around Península Valdés. The rocks in this region are nearly flat-lying and consist of nearshore interbedded sandstones and tuffaceous siltstones. The sequence at Punta Cracker on the southwestern shore of Golfo Nuevo (Fig. 1) represents a prograding nearshore-beach facies changing from shallow marine to beach-lagoon deposits. Earlier investigators (*4, 5*) have referred the shallow marine facies to the Entrerriense and the beach-lagoonal facies to the Rionegrense.

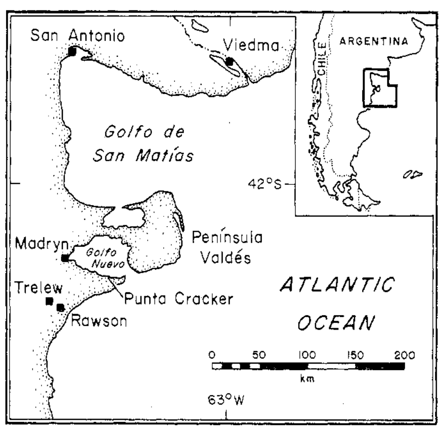

Fig. 1. Map of the northeastern coast of Patagonia, showing the location of Punta Cracker.

Samples of a whitish tuff 2 m thick from near the top of the Rionegrense horizon at Punta Cracker were collected and dated by the ^{40}K-^{40}Ar method (*8*). Three glass concentrates gave dates ranging from 9.11 (sample KA 3509) to 9.56 (sample KA 3633) $\times 10^6$ years (mean = 9.41 $\times 10^6$ years) (Table 1). These dates correlate with the Late Miocene Tortonian marine stage in Europe (*9*) and the Chasicoan Land Mammal Age in South America (*10*). Because of the cyclic nature of the Neogene transgressions in northeastern Argentina, it is probable that deposits elsewhere referred to the Rionegrense may be older or younger than those at Península Valdés.

Table 1. Analytical data for vitric concentrates of tuff dated at Punta Cracker (*8*).

Sample number	Sample weight (g)	K (%)	Radiative ^{40}Ar ($\times 10^{-11}$ mole/g)	Atmospheric ^{40}Ar (%)	Age ($\times 10^6$ years)
KA 3509	1.0193	3.48	5.52	54	9.11 ± 0.1
KA 3633	5.7335	3.23	5.38	46	9.56 ± 0.3
KA 3510	0.3301	3.43	5.69	73	9.55 ± 0.3

WILLIAM J. ZINSMEISTER
Institute of Polar Studies, Ohio State University, Columbus 43210
LARRY G. MARSHALL
Department of Geology, Field Museum of Natural History, Chicago, Illinois 60605
ROBERT E. DRAKE
GARNISS H. CURTIS
Department of Geophysics, University of California, Berkeley 94720

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8. The ^{40}K-^{40}Ar dates are based on glass concentrates of a water-laid tuff containing abundant ripple marks. The concentrates were composed of primary volcanic glass shards obtained by heavy liquid separation with bromoform. This separation technique effectively removed fine-grained biotite flakes and other detrital material. Each date was obtained on a different sample of tuff, and in each case separate preparations were used. These facts and the consistently similar dates demonstrate repeatability and high reliability for the age of this tuff. Calculations are based on the decay constants $^{40}K\lambda\beta = 4.962 \times 10^{-10}$ year^{-1} and $\lambda^{40}K^e + {}^{40}K^e = 0.581 \times 10^{-10}$ year^{-1} and on the isotope abundance ^{40}K = 0.01167 percent of the total potassium.
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