Chapter 5
New Evidence for a Possible Paleolithic Occupation of the Eastern North American Continental Shelf at the Last Glacial Maximum

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Introduction

Researchers have postulated the presence of submerged archaeological deposits on the Middle Atlantic continental shelf of North America for decades (Emery and Edwards 1966; Edwards and Emery 1977; Kraft et al. 1983). However, archaeological discoveries on the continental shelf made during commercial shellfish dredging have gone unrecorded or have escaped detection. By contrast, numerous vertebrate remains including the bones, teeth, and skulls of mammoth, mastodon, and walrus

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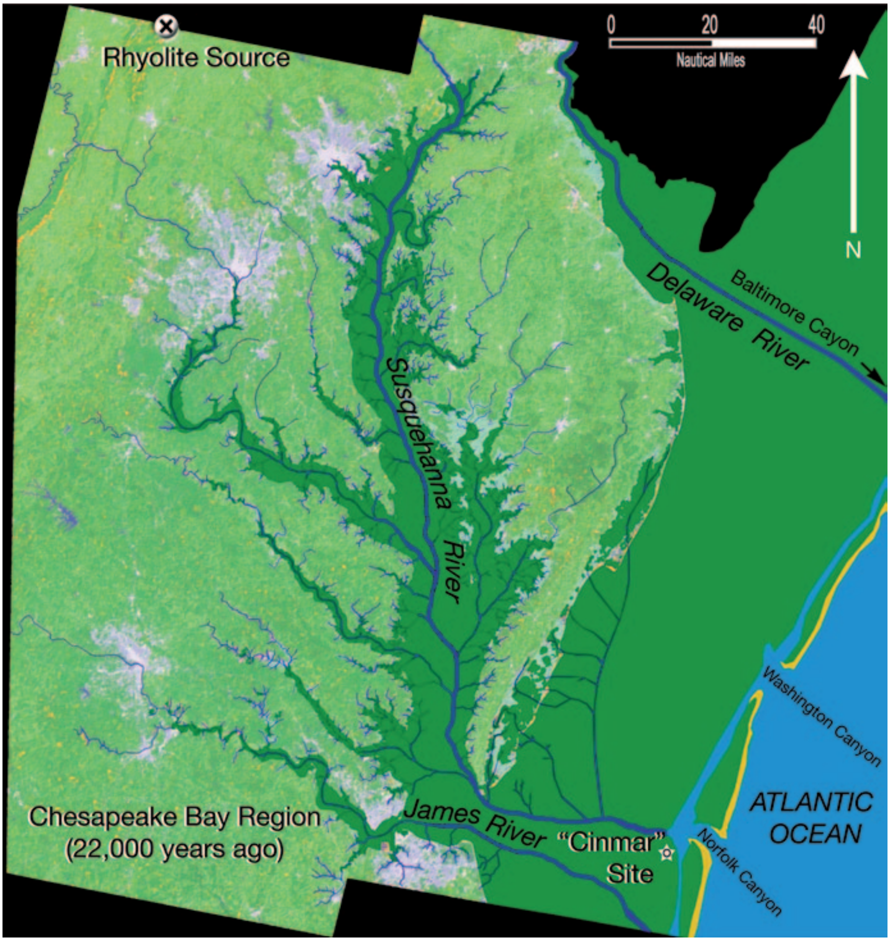

Fig. 5.1 Last Glacial Maximum Susquehanna River drainage showing locations of the Cinmar site and Ryolite Quarry

have been reportedly discovered by deep-sea fishermen and dredgers on the continental shelf (Edwards and Merrill 1977; Whitmore et al. 1967).

In 1974, Captain Thurston Shawn and the crew of *Cinmar*, a scallop trawler working 100 km east of the Virginia Capes, were dredging at a depth of 70 m (Fig. 5.1). Just after starting their run, the dredge became very heavy and when reeled in, it contained a mastodon skull. While cleaning the bone from the dredge, a large bifacially flaked rhyolite knife was discovered. Shawn carefully plotted the water depth and the exact location of the find on his navigation charts and noted that all of these items were dredged at the same time. To expedite getting back to dredging, the *Cinmar* crew broke up the skull and removed the tusks and teeth for souvenirs, throwing the rest of the bone overboard. Later the tusks were sawn into pieces and distributed among the crew.

Table 5.1 Measurements and proportions (in mm) of the Cinmar stone tool

Length	186 (est. 190)	Length/maximum width	3.5
Maximum width	54	Maximum width/thickness	7.7
Thickness	6 (at maximum width)		
Width at 1/4 length	44	Width at 1/4 length	7.3
Width at 1/2 length	53	Width at 1/2 length	6.6
Width at 3/4 length	39	Width at 3/4 length	4.3 (at "stack")
Thickness at 1/4 length	6	Mean width (n=4)	6.5
Thickness at 1/2 length	8		
Thickness at 3/4 length	9		

Captain Shawn retained for himself a tusk section, a complete tooth and the biface, and gave one of the molars to his sister, Mrs. Sylvia Cannon of Mathews, Virginia. Shawn was not an artifact or fossil collector and, subsequently, sold his specimens to Dean Parker of Hudgens, Virginia. Parker in turn loaned them to the Gwynn's Island Museum where they have been on exhibit since 1974 (Stanford and Bradley 2012).

The significance of the *Cinmar*'s discovery was not recognized until Darrin Lowery conducted an archaeological survey in Mathews County, Virginia, and saw the biface, mastodon tooth, and tusk segment at the museum. Subsequent interviews with Captain Shawn and his sister confirmed the fact that all of the specimens were recovered at the same time and place, as described here. The importance of the Cinmar evidence concerning the timing of the New World settlement and human occupation of the now-submerged coastal settings initiated the study reported here.

The find location, designated the Cinmar site, is on the edge of the outer continental shelf, south of the last glacial maximum (LGM) Susquehanna Paleo-River Valley, which is referred to as the Cape Charles channel (Fig. 5.1). During the LGM, 19,000–26,500 years ago (Clark et al. 2009), sea stand is estimated to have been 130 m below the present sea level (Milliman and Emery 1968; Belknap and Kraft 1977). The site was on the edge of the LGM James Peninsula, immediately west of a LGM barrier island and channel. This terrestrial landscape, which existed between at least 14,500 years ago and possibly more than 25,000 years ago, would have been 10–14 meters below sea level (mbsl) by the time Paleoindians occupied North America approximately 13,500 years ago (Waters and Stafford 2007).

The Cinmar stone tool is a large, thin knife with evidence of well-controlled percussion thinning flake scars on both faces (Fig. 5.2). It represents the workmanship of a highly skilled flint knapper because rhyolite is very difficult to flake correctly. The obverse face has a full face, possibly large overshot flake across the basal half. Because the overshot flake resulted in the removal of an excessive portion of the artifact's surface, subsequent flaking adjustments were made, resulting in a slight longitudinal curve and variable thickness. For measurements and proportions of the Cinmar stone tool, see Table 5.1.

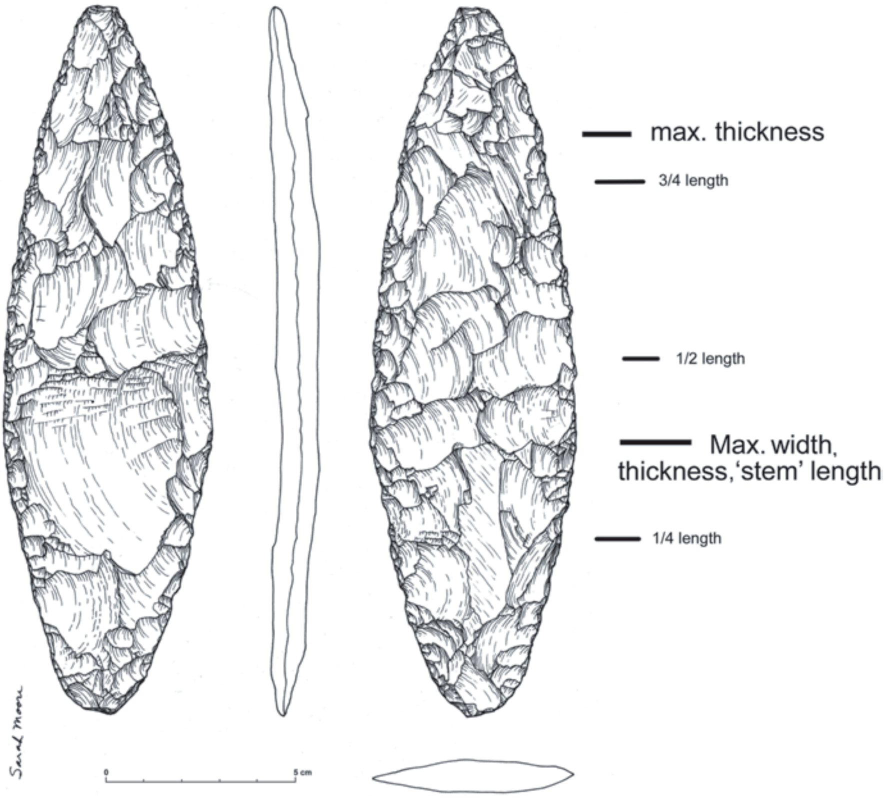

Fig. 5.2 The Cinmar Biface

Use-Wear Evaluation of the Cinmar Biface

High-power microscopic examination of the artifact using a reflected light, differential-interface binocular microscope with polarized light and Nomarski optics ranging between 100 and 400 diameters identified linear microstriations and polishes typical of knife use, including up-and-down and back-and-forth movements on the distal surfaces of the blade. The proximal end (base) exhibits microscopic linear striations that are typical of haft wear. Evidence that the knife was resharpened before being lost or discarded consists of noninvasive percussion retouch along the distal edges that is not overprinted by use-wear traces. The preserved condition of the flake scars, together with the preservation of surface microstriations and polish, indicate that the biface did not experience episodes of redeposition by water transport, nor was it abraded by surf action.

Separating the irregular crystal polygons evident on the banded rhyolite reference specimens and the artifact from microscopic wear traces proved a simple task, as the wear traces are largely striated residues, or additive "microplating" features, which develop progressively with tool use (Kay 1996, 1998). Microplating residues are impervious to ultrasonic cleaning with concentrated strong alkali (KOH) and acid (HCL), and occur on siliceous artifacts from varied depositional environments and ages in excess of at least 100,000 years. Experimentation demonstrates that microplating residues develop and harden coincident with tool use, are a biochemical byproduct of moisture and direct contact with a material worked by a stone tool or adhering to it, and, in an elegant way, express tool motion kinematics. Characteristic of microplating residues are flow features; among them are filled-in striations, desiccation cracks on drying, abrasive particle capturing, and crystallization filaments. Abrasive particles and crystallization filaments occur on the trailing edge or surface opposite the direction(s) of movement of a tool stroke. They are also instructive of handholding the tool or complementary movement of the tool in its handle. Microplating features are ubiquitous on the artifact and overprint other tool use-related abrasion and abrasive wear traces. They do not occur on an examined banded rhyolite comparative specimens and are easily distinguished from the irregular crystal polygons. These wear traces fall into two complementary categories, due to either use or from movement in a handle.

The Cinmar biface has diagnostic and common wear traces characteristic of having been a hafted knife. The haft wear traces do not resemble those far less developed and readily observed from handholding an experimental stone knife. The haft element wear traces (Fig. 5.3, *i*) are the mirror opposite of the blade element. These wear traces are indicative of complementary movement within the handle as a result of tool use. Haft wear includes more extensive abrasive rounding of arises but not true abrasive planing. The cutting wear traces (Fig. 5.3, *j*) are invasive and originate on either blade edge and at the broken tip. Multiple tool strokes are recorded oblique to the two blade edges and from the tip. The final tool strokes appear to be directed from the tip, and either further penetrated or were withdrawing from the worked material. Blade edge angles vary from 55° to 75°. Haft edge angles are 50° or less. Blade edge steepening with use and resharpening seem likely, especially since the blade edges only occasionally have use-wear. Most often the wear traces are on the older and higher flake arises, and it was easiest to track them to these spots. The blade edges are damaged, mostly rounded and crushed with micro step fractures. The invasive cutting wear, the tool edge damage, and experimental analogs all point to this knife having cut through a material that enveloped its surfaces while breaking and dulling the tool edges too. The contact material would have had paradoxical qualities—hard and unyielding and yet soft and allowing deep penetration. Consistent with experimental tool use-wear analogs, the likely and predominant contact material would have been bone and cartilage within a carcass. This tool appears to have been a heavy-duty butchering knife that was sharpened at least once and that ultimately failed in use (Fig. 5.4).

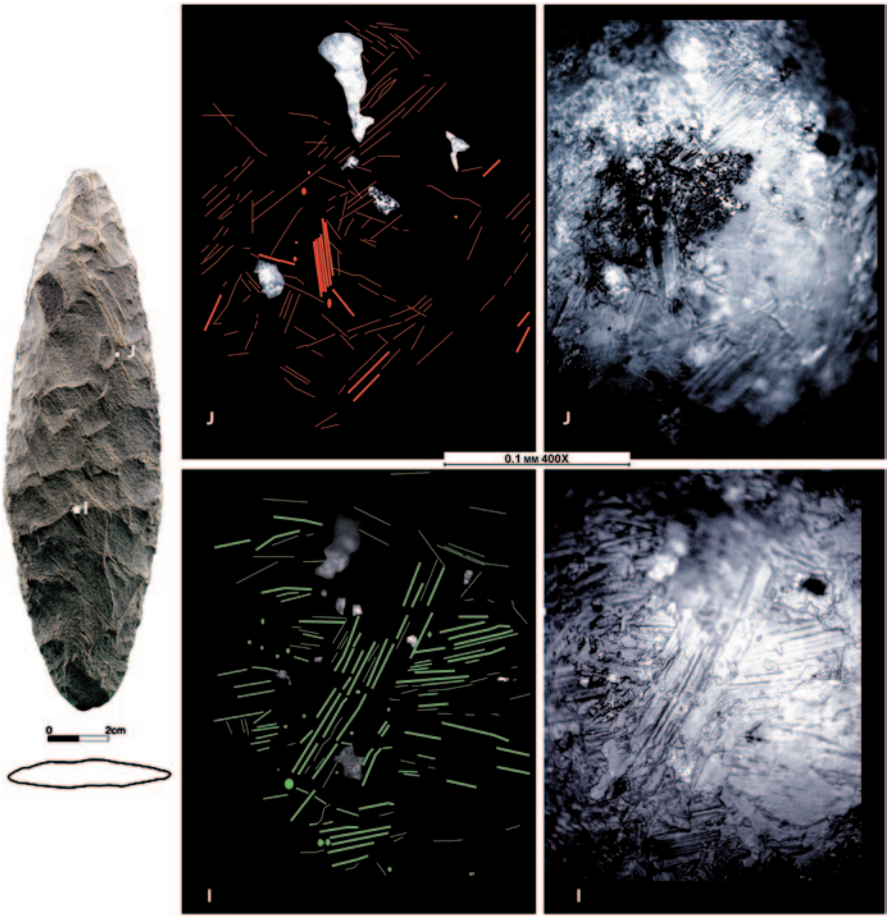

Fig. 5.3 Oriented photomicrographs of microplating residues and kinematic diagrams of striations (*colored linear features*), abrasive particles (*ovals*) and crystallization filaments (*gray-white "cloud" features*) for areas *i* and *j* on reverse face of the Cinmar artifact. The inferred directions of movement for each location are the mirror opposite of the other: area *i* pertains to the haft element, area *j* the blade element. The final movement is, respectively, diagonal to the longitudinal axis for the haft element (*i*) and just slightly off parallel to the longitudinal axis and bidirectional for the blade element (*j*)

Identification of the Source of the Rhyolite Used to Make the Cinmar Biface

Volcanic rocks, such as obsidian and rhyolite can be linked to their geologic source with a high degree of reliability by using analytical techniques such as instrumental neutron activation analysis (INAA), X-ray fluorescence (XRF), and inductively-coupled plasma mass-spectrometry (ICP-MS). These volcanic rocks typically occur

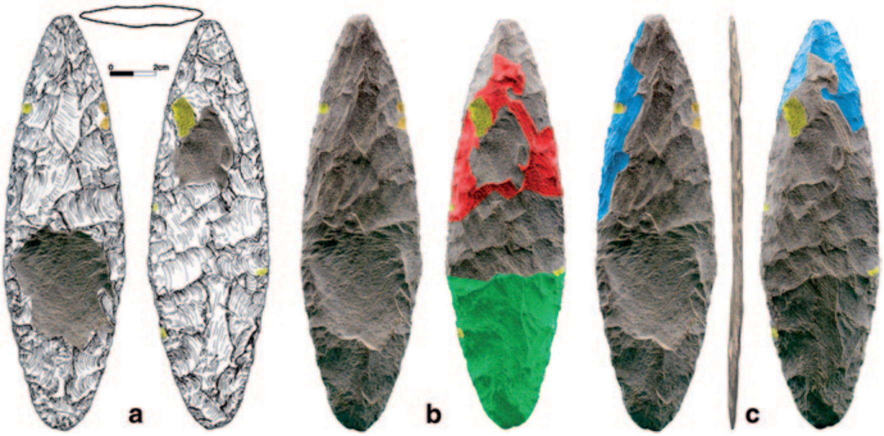

Fig. 5.4 Use history diagram for the Cinmar biface artefact. **a** Primary (*gray shaded areas*) and mostly secondary flaking that crosscuts the recently damaged areas exposing the original cortex (*shaded yellow*) on both faces. **b** Functional zones identified by microscopic evaluation of use-wear on reverse face (haft element is *shaded green*, blade element cutting wear is *red*). **c** Blade element resharpening (*shaded blue*) on both faces

in spatially discrete and relatively localized contexts. Such sources are typically chemically homogeneous, and individual sources have unique chemical characteristics. With sufficient field and laboratory work, the spatial extent of a specific geochemical type of volcanic rock, including primary and secondary deposits, can be established such that a source area can be defined (Speakman et al. 2007; Glascock et al. 1998).

As a starting point for the geochemical source study, more than 350 vouchered rhyolite specimens from eastern US localities ranging from Maine to North Carolina (e.g., rhyolite, metarhyolite, and felsite) housed in the Rock and Ore Collection of the Smithsonian Institution's National Museum of Natural History, Department of Mineral Sciences, were visually examined. More than 30 samples exhibiting banding, as well as a few random samples, were analyzed by XRF and compared to data from the Cinmar biface. When compared to other geologic samples from the Eastern US, the Cinmar biface is chemically and visually distinct because of its high (>800 ppm) Zirconium (Zr) content and its unique banding and color.

Of the eastern US rhyolite samples examined in the National Museum of Natural History's mineral collection, only one was identified as a likely match: a sample of banded metarhyolite (NMNH 60892) from the Catoctin formation of South Mountain, Pennsylvania. The specific provenance of the sample is listed as "Maria Furnace Road, 1 mile from Tom's Creek Railroad Trestle." The sample presumably was collected by Smithsonian archaeologist W.H. Holmes who visited and described the quarry in 1893–94 (Holmes 1897). Maria Furnace is ca. 10 miles southwest of Gettysburg on Toms Creek, which is a branch of the Monocacy River. Following the identification of the probable source as South Mountain, the authors visited the Maria Furnace locale and collected additional rhyolite samples for XRF analysis.

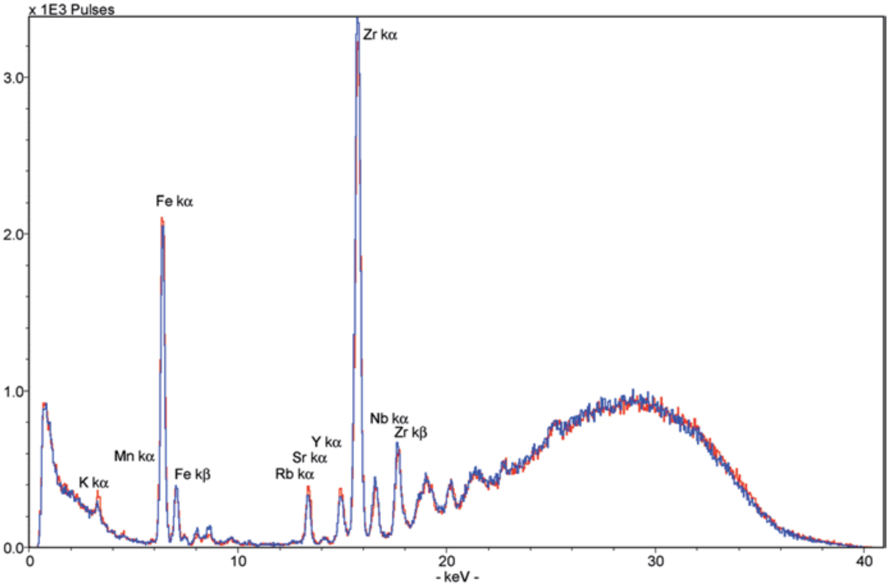

Fig. 5.5 Comparison of XRF spectra from the Cinmar biface (*blue*) and NMNH 60892 (*red*)

XRF analyses were conducted using a Bruker AXS Tracer III-V XRF. The analyses permitted quantification of the following elements: Mn, Fe, Ga, Rb, Sr, Y, Zr, Nb. The artifact and geologic specimens were analyzed as unmodified samples. The instrument is equipped with a rhodium tube and a SiPIN detector with a resolution of ca. 170 eV FHWM for 5.9 keV X-rays (at 1,000 counts/s) in an area 7 mm^2. All analyses were conducted at 40 keV, 15 μA, using a 0.076-mm copper filter and 0.0306-mm aluminum filter in the X-ray path for a 200-s live-time count. Peak intensities for the above listed elements were calculated as ratios to the Compton peak of rhodium, and converted to parts-per-million (ppm) using linear regressions derived from the analysis of 15 well-characterized rhyolitic glasses that previously had been analyzed by neutron activation analysis (INAA) and/or XRF.

Metarhyolite from South Mountain is widely recognized as a major lithic source used for production of prehistoric stone tools throughout the US Middle Atlantic Region (Stewart 1984, 1987) and an unpublished INAA study (Bonder 2001) has demonstrated that metarhyolites from South Mountain are chemically discrete from other sources in Maryland, Virginia, and North Carolina. Both visual examination and chemical analysis confirm that the material used to manufacture the Cinmar biface originated from the South Mountain Catoctin formation. Examination of the XRF spectra (Fig. 5.5) and the plots of the data (Fig. 5.6) demonstrate that rhyolite from outcrops near Maria Furnace are most similar chemically to the Cinmar biface. The authors caution, however, against stating that the stone used to produce the Cinmar biface originated from the vicinity of Maria Furnace given that numerous Catoctin formation metarhyolite outcrops occur throughout the South Mountain area of the Pennsylvania Blue Ridge.

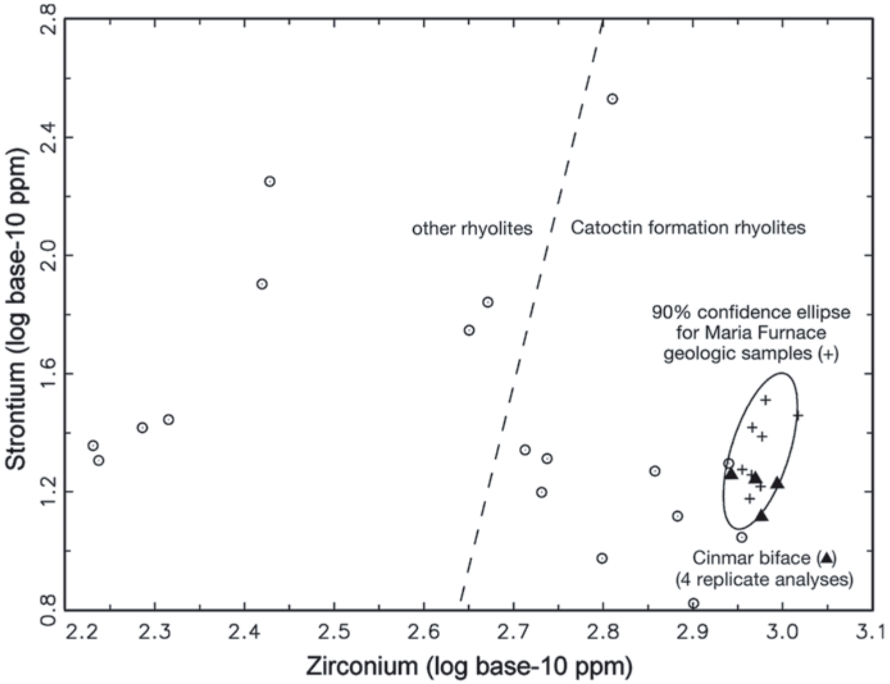

Fig. 5.6 Plot of zirconium and strontium-based ten logged concentrations for samples analyzed by XRF. Data for the Cinmar biface (two replicates are projected against the 90 % confidence ellipse calculated from six Maria Furnace geologic samples and two replicate analyses of NMNH 60892, also from Maria Furnace)

The Mastodon, Carbon Fourteen Dates, and Environment

The diameter of the mastodon tusk section is small, measuring 83 × 73 mm. The tooth, an upper right third molar, is also small, measuring 90 mm in width across the tritoloph and 155 mm in length. Wear on the tooth has entered stage 2, indicating a mature animal of approximately 30 years of age (Saunders 1977). The size and age characteristics of the molar and tusk indicate that the Cinmar mastodon was a small female.

Two sections of the tusk were sampled to obtain bone collagen for accelerator mass spectrometry, 14C dating. The resulting age was 22,760 ± 90 RCYBP (UCIAMS-53545). This age determination is consistent with the LGM sea level data and led the authors to conclude that the mastodon died on the outer margin of the continental shelf during the initial phase of the last glacial maximum.

Limited data are available for environmental reconstruction of the mid-Atlantic outer continental shelf during the last glacial maximum. Freshwater peat dated to 15,500 years ago was dredged from depths of 64–66 m (210–216 feet) near the Washington Canyon, north of the Cinmar site (Emery et al. 1967). Pollen extracted from the peat suggests that spruce, water lily, sedge, pine, oak, and fir were growing on the continental shelf shortly after the last glacial maximum. Another pollen sample, recently extracted from a soil sample taken from the Miles Point site dated to greater than 25,500 years ago on the Eastern shore of the Chesapeake, and revealed krummholz yellow birch, red spruce, balsam fir, and C3 grasses (Lowery et al. 2010). These data are evidence that the adjacent terrestrial vegetation likely extended as an unbroken biome onto portions of the continental shelf that were dry land during the LGM. The likelihood of abundant freshwater springs and ponds along the margin of the continental shelf (Faure et al. 2002), and the shrubby environment of the adjacent inter barrier island lagoon, as well as a relatively large number of mastodon remains reported from the continental shelf (Whitmore et al. 1967), indicate an ideal environment to support a reasonable mastodon population.

Rhyolite Artifact Weathering and Patination in Coastal Plain Environments

The Atlantic coastal plain contains a mix of chemical conditions and environments that can differentially affect rhyolite (Lowery and Wagner 2012). Rhyolite or methyolite artifacts that are buried quickly retain a fresh appearance (Fig. 5.7a). Conditions for rapid burial usually include anthropogenic features created by human activities. Natural processes also rapidly bury rhyolite artifacts and can result in fresh unweathered appearances. If a rhyolite artifact erodes from an upland setting via fetch-related coastal processes, prolonged exposure to the “swash and berm” zone results in abraded, smoothed surfaces with rounded edges (Fig. 5.7d). The rhyolite specimen shown in Fig. 5.7d is also patinated, however, the edges and surface of the point are rounded and polished due to prolonged tumbling and abrasion in the surf. Inevitably, tidal marshes accrete over former uplands as a byproduct of marine transgression.

As a result of the formation of an overlying tidal marsh, iron-rich rhyolite artifacts situated within the submerged upland stratum, like Fig. 5.7a, will undergo *sulfidization* in the organic-rich anaerobic surroundings. Because the iron in the rock is chemically altered to dark-colored iron sulfide, the outward appearance of the rhyolite artifacts in these settings may become darker, resembling the fresh forms of rhyolite. Slow rates of sea-level rise can erode the archaeological deposits from the drowned upland stratum beneath the tidal marsh peat. In these environments, the sulfidized rhyolite artifacts from beneath the anaerobic tidal marsh will be subjected to aerobic conditions in the nearshore area. During periods of rapid marine transgression, however, tidal marshes become inundated and bioturbation by marine organisms will reintroduce oxygen to the underlying archaeological deposits. In either of these aerobic settings, the reoxygenated iron-rich artifacts will undergo the *sulfuricization* process. As a result, a uniform chemically related sulfuric acid corrosion patina will develop (Fig. 5.7b) on rhyolite artifacts. In buried or intact settings, rhyolite artifacts will retain sharp cutting edges and any original use wear (Fig. 5.7c). In abrasive, exposed nearshore and offshore areas, artifacts can

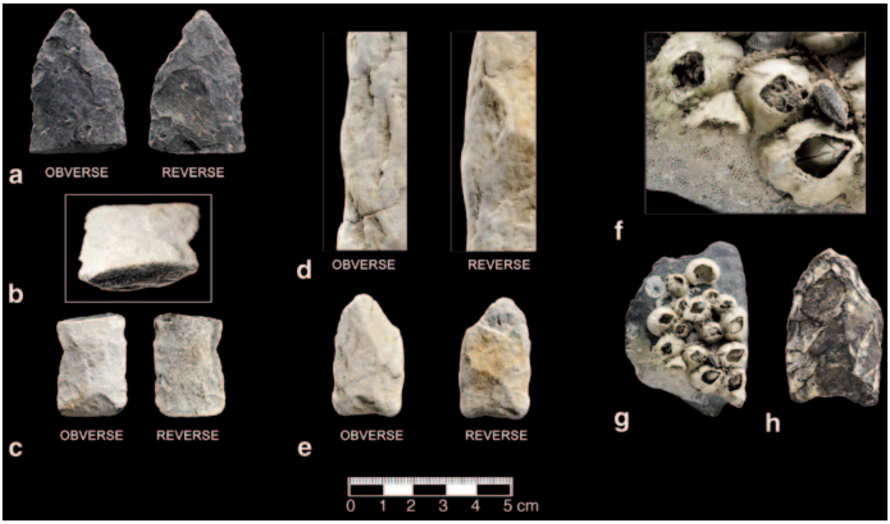

Fig. 5.7 Rhyolite artifacts exposed to marine and near shore environments. **a** Unaltered artifact from a buried onshore environment. **b**, **c** Artifacts patinated by chemical corrosion. **d** Edge of artifact subjected to prolonged abrading in the surf. **e** Chemically corroded artifact subjected to surf abrasion. **f**–**h** Marine organisms attached to rhyolite artifacts

become dislodged from the intact drowned archaeological deposits. Under these conditions, the edges of artifacts become heavily rounded (Fig. 5.7d–e). Depending on the proximity to the coastline, the dislodged artifacts are tumbled and rounded by currents in offshore sub-tidal settings or transported to abrasive nearshore areas. Artifacts exposed for protracted periods of time on the surface of the water bottom will generally accumulate a mix of attached marine organisms (Fig. 5.7f–h). For a full-detailed discussion of both the *sulfidization* and the *sulfuricization* process in nearshore coastal settings see Lowery and Wagner (2012, pp. 690–697). In contrast to the variables impacting rhyolite artifacts along shorelines, similar artifacts deposited on interior upland archaeological site surfaces will only develop a patina on surfaces that have been exposed skyward.

The unrounded surfaces retaining use wear with relatively sharp cutting edges and even patination of the Cinmar biface indicate that the artifact originated from an intact archaeological deposit. As a result of elevated sea levels at the end of the Ice Age, ca. 14,500 years ago, tidal marsh peat developed over the archaeological deposit containing the Cinmar biface. As a result, the iron in the rhyolite underwent the *sulfidization* process associated with a brief exposure to the organic carbon-rich anaerobic tidal marsh surroundings. The accelerated sea level rise during Meltwater Pulse 1A quickly inundated the tidal marsh, and bioturbation from the offshore marine organisms reintroduced oxygen to the underlying archaeological deposit. The introduction of oxygen caused the Cinmar biface to undergo the effects of *sulfuricization*. Like the specimen shown in Fig. 5.7b–c, a uniform, chemically mediated, corrosion patina developed. Unlike the specimen shown in Fig. 5.7b–c, the sulfuric acid

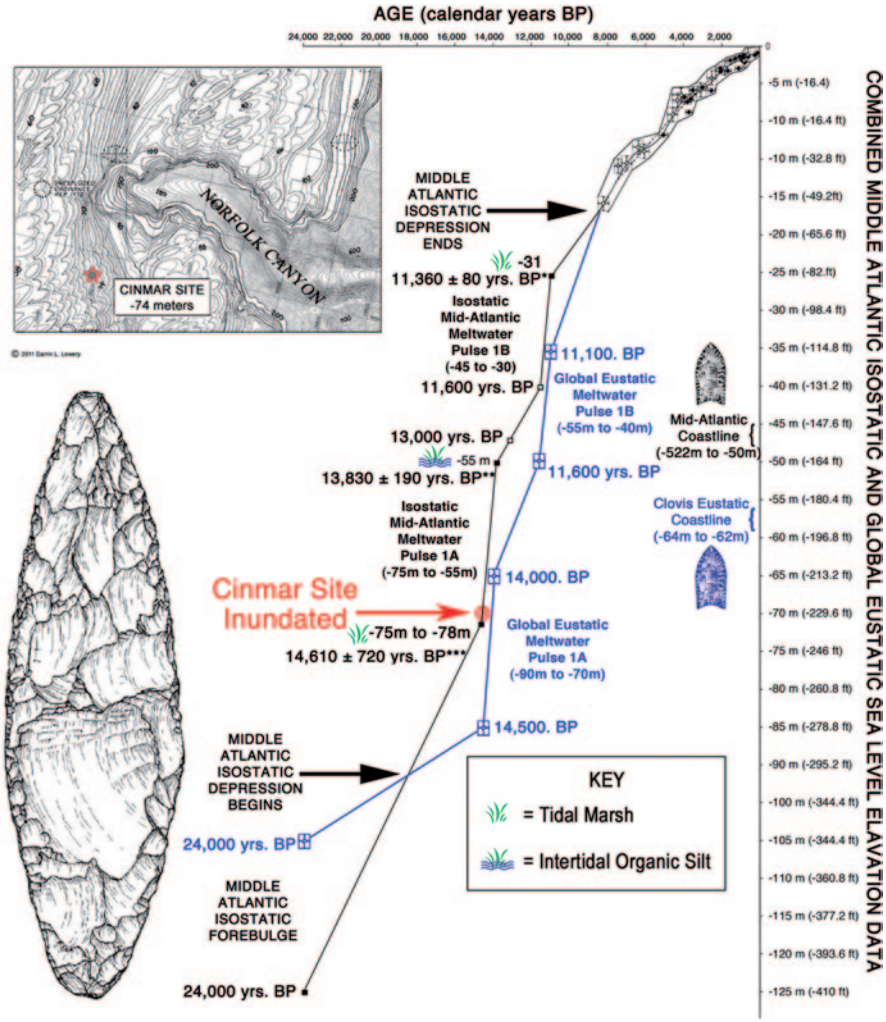

Fig. 5.8 The Cinmar site relative to Middle Atlantic Isostatic and Global Eustatic Sea Level data. (Based on Mallinson et al. 2005; Oldale et al. 1993)

corrosion patina on the Cinmar biface is noticeably less. The degree of patina can be equated to the duration of exposure to the anaerobic conditions when buried beneath an overlying tidal marsh. Given the slow rates of late Holocene sea level rise (Fig. 5.8) for the Middle Atlantic (Nikitina et al. 2000) and the documented one-meter thickness of tidal marsh peat overlying the drowned archaeological deposit that produced the artifact shown in Fig. 5.7b–c, the authors conclude that this artifact was subjected to at least 1,000 years of exposure to *sulfidizing* anaerobic conditions.

Lowery and Wagner (2012) have concluded that *sulfuricization* can occur very rapidly once aerobic conditions are restored. In contrast, the setting associated with the Cinmar biface was exposed to *sulfidizing* anaerobic conditions of a tidal marsh for only a short period of time. The shortened duration and exposure to *sulfidizing* conditions resulted in limited patination to the surface of the Cinmar biface once the site was completely drowned and aerobic conditions were restored. The rates of sea-level rise (3.7–4 m per century) postulated at the onset of Meltwater Pulse 1A c 14,500 years ago (Weaver et al. 2003) would mean that the Cinmar site was situated in a nearshore tidal marsh environment for only a short period of time. The resultant situation limited the artifact's exposure to *sulfidizing* conditions and the rapid rates of marine transgression inundated the site before the archaeological deposit was eroded or disturbed.

A detailed overview of the chemical conversion of iron oxides to iron sulfides in coastal setting soils has been presented by Fanning et al. (2010) and the same process seems to impact iron-rich silicate artifacts in coastal tidal marsh settings (Lowery and Wagner 2012). The rapid conversion of iron oxides in stone artifacts to iron sulfides takes place chemically by reaction with dissolved sulfide in sea water. The chemical reaction represents the microbial reduction of sulfate during oxidation of organic matter in tidal marshes. The reduction of iron oxides in stone artifacts by hydrogen sulfide results in the formation of both iron monosulfides and iron disulfides (pyrite). The black monosulfides that result tend both to form quickly and to fade quickly upon exposure to oxygen. Exposure to oxygen can be the result of bioturbation in an offshore setting or simply a by-product of being brought to the surface. Pyrite (FeS_2) takes more time to form in an artifact and it is more persistent after formation. With respect to the patination observed on the Cinmar biface, some portion of the iron oxide in the parent rock was also altered to pyrite by long-term exposure to the anaerobic conditions of a tidal marsh. When a stone artifact experiences an aerobic environment, acidity is generated from the oxidation of the sulfides, and the hydrolysis of the iron. Bioturbation within a drowned tidal marsh peat deposit introduces oxygen into the deeper anaerobic strata. In an aerobic setting, the surface of the artifact creates its own chemical weathering patina.

When the Cinmar biface was dredged from the bottom, it was already patinated. The conditions outlined above would explain why the Cinmar biface is uniformly weathered or patinated on all surfaces, which is unlike the asymmetrical patination typical of rhyolite artifacts lying on the surface in a terrestrial environment.

Questions of Association

The question of whether or not the biface was associated with the mastodon remains is critically important for an accurate interpretation. Did Paleolithic people use the knife while butchering the mastodon or was the close spatial relationship fortuitous? There are three kinds of events that might have produced a spurious association between the artifact and the mastodon remains: lateral transport, prehistoric coincident, and fraud. These possibilities are dealt with in turn.

Lateral Transport

The biface was initially deposited elsewhere and was transported to a location near the mastodon remains via fluvial or tidal processes, or perhaps even dredged from another location some distance away from the mastodon bone. The authors reject this hypothesis for the following reasons:

Redeposition of a large stone tool in a high energy water transport system is known to produce taphonomic alterations that modify flake scars and tool edges, and overprint microscopic use-wear polish and striations with signatures of transport that include fractured or rounded tool edges (Shea 1999; Grosman et al. 2011), flattening of dorsal ridges, and patterns of abrasion that are similarly expressed on the distal and proximal ends of artifacts subjected to redepositional forces. The combined effects of sediment and debris-laden ocean currents tumbling the knife, had it washed out to sea, would have compromised the flake ridges and knife edges and obliterated the microscopic polish and use-wear scars. Moreover, lithic artifacts eroded from coastal prehistoric sites stay within the "swash and berm" zone (Lowery 2003) and move laterally along the shoreline, and over the long-term they are redeposited inshore, not offshore (Lowery 2008).

It might be conjectured that the knife was dredged and dragged from another location before the trawler hit the mastodon remains. This hypothesis is rejected for the following reasons:

- The dredge consists of a welded iron frame with a flat iron bar that drags along the bottom. As the flat iron bar at the bottom of the dredge scrapes the sea floor, scallops and other objects on the surface of the sea floor enter the dredge and are captured. Behind the dredge is a large enclosure with a series of welded iron bars with interwoven iron rings, or a monofilament seine-like bag. The sizes of the interwoven iron rings vary but the mesh is generally between 4 and 5 in. (~ 10 and 13 cm). The mesh size limits what is retrieved from the bottom. Smaller objects usually slip through the rings and only the larger objects are brought to the surface. Archaeological objects on the Middle Atlantic continental shelf may have escaped detection by commercial shell fishermen because small artifacts such as debitage, flake tools, and projectile points less than 10–15 cm lying on the surface of the continental shelf would easily fall through the larger size of mesh of the equipment used to scrape the bottom for scallops before being lifted to the surface. The large size of the dredge scalloping mesh may explain why large Ice Age animal remains are commonly reported from drowned localities on the Middle Atlantic continental shelf, while lithic or bone artifacts are rarely reported. In the case of the discovery made by Captain Thurston Shawn, the large size of the artifact allowed it to be recovered.
- The scallop dredge is tethered to the boat by a line or a large cable. Scallop fishermen prefer to dredge stretches of the ocean floor with common or uniform bathymetric depths to ensure that the dredge remains on the bottom. The distance that a dredge travels across the bottom at a common or uniform bathymetric

> depth can vary greatly. Generally, the captain or crew gauge the dredge retrieval time based on the stresses placed on the boat. The stresses on the boat are caused by the weight of material trapped in the dredge. As such, a scallop dredge can be pulled across the sea floor for either short or long distances. The distance traveled across the floor depends on how quickly the dredge is filled with scallops and other debris. In the case of the Cinmar discovery, the stress caused by the weight of a mastodon skull and associated tusks caused the transect run to be terminated and the dredge pulled and cleaned as soon as the remains were encountered. Because the biface was only slightly damaged by the iron frame, bars and rings of the dredge the artifact was not pulled for any distance across the sea floor, and therefore was dredged at relatively the same time as the mastodon remains.

The interpretation is that, the skull and knife were deposited together as part of a single archaeological assemblage. Again, if they were moved for any significant distance by the dredge, they would have been heavily damaged by tumbling in the metal framework of the trawler's net. Moreover, Shawn reported that they had just begun a transect when they encountered the heavy weight of the bones causing the net to be reeled in unexpectedly. Trawlers in this area run parallel to the coastline in order to maintain a constant fishing depth, so if the knife was not associated with the bone, it would have been situated at the same elevation, and because of the anaerobic modification of the rhyolite it would have had to have been dredged from an ancient saltwater marsh, as were the bones. Thus, given the fresh untumbled surfaces and sharp edges of the Cinmar biface, and the matching amount of oxidation color change on both the biface and mastodon remains, the authors conclude that the knife originated from an archaeological deposit associated with the mastodon or near where the mastodon was dredged from the sea floor.

Prehistoric Coincident

The knife was lost or deliberately thrown overboard by a prehistoric mariner traveling the ocean subsequent to sea-level rise and it came to rest with or near the mastodon.

The authors submit that hypothesis 2 is a priori extraordinarily weak because of the near absence of laurel leaf bifaces in the later middle Atlantic archaeological record, coupled with the odds against some prehistoric hunter losing a knife while on an ocean voyage some 100 km out in the Atlantic and that same knife settling down over 70 m onto the same area in the ocean floor where a mastodon died millennia earlier. Moreover, if such an event had transpired, the artifact would not have been subjected to the chemical environment that caused the geochemical patination and weathering of its surfaces. The 16 m or more rise in eustatic sea level in less than 300 years quickly drowned the tidal marsh and the sediments were partially oxidized.

The short-term exposure of the iron-rich stone artifact to the anaerobic conditions of the tidal marsh limited the degree of patination; however, the localized acidic condition created by the reoxygenation of the site resulted in a uniform color change of both faces of the knife.

Fraud

The association of the knife and the mastodon skull was fabricated. This hypothesis is rejected because the discoverers received no glory from their find, unlike the typical archaeological fraud. Moreover, it would seem unlikely that from all the artifacts that would have been accessible for fraudulent activities, the perpetrators of a fraud would likely not have had a rare laurel leaf biface, let alone that they might understand the cultural and temporal significance of a laurel leaf. It is important to remember that both the mastodon remains and the biface had also been on display since 1976 with a label outlining the circumstances of their discovery.

Thus, the authors conclude that the Cinmar discovery has major implications for understanding New World prehistory. If the artifact is associated with the 22,760 RCYBP radiocarbon date, it would imply that humans were living on the LGM continental shelf of eastern North America at least 10,000 years before any other reliable radiocarbon dated archaeological sites. If it is not associated with the mastodon in the freshwater marsh, the biface would be no younger than the saltwater marsh formed at the onset of Meltwater Pulse 1A, making it at its youngest 2,000 years before the advent of Clovis, and is the oldest dated formal tool yet found in the Americas.

The distance from the Cinmar site to the rhyolite sources in Pennsylvania is nearly 320 km, suggesting that by the time the Cinmar biface was manufactured, early cultures had explored the interior of the Chesapeake drainage basin and discovered useable stone resources. Therefore, the Cinmar date is an estimate for the timing of human occupation in eastern North America and it nearly doubles the length of human occupation in the New World.

Chesapeake Bay Bifaces

The Cinmar biface is typologically unusual for the Middle Atlantic region. It is significant that only three laurel leaf-shaped bifaces were identified during an inventory of the Smithsonian Institution's extensive archaeological collection of nearly 300,000 artifacts from the Middle-Atlantic region representing Paleo-Indian through historic time periods. The authors also examined private collections from the region, collections at artifact shows, and conducted an artifact identification weekend at Gwynn's Island that resulted in identifying eight additional bifaces.

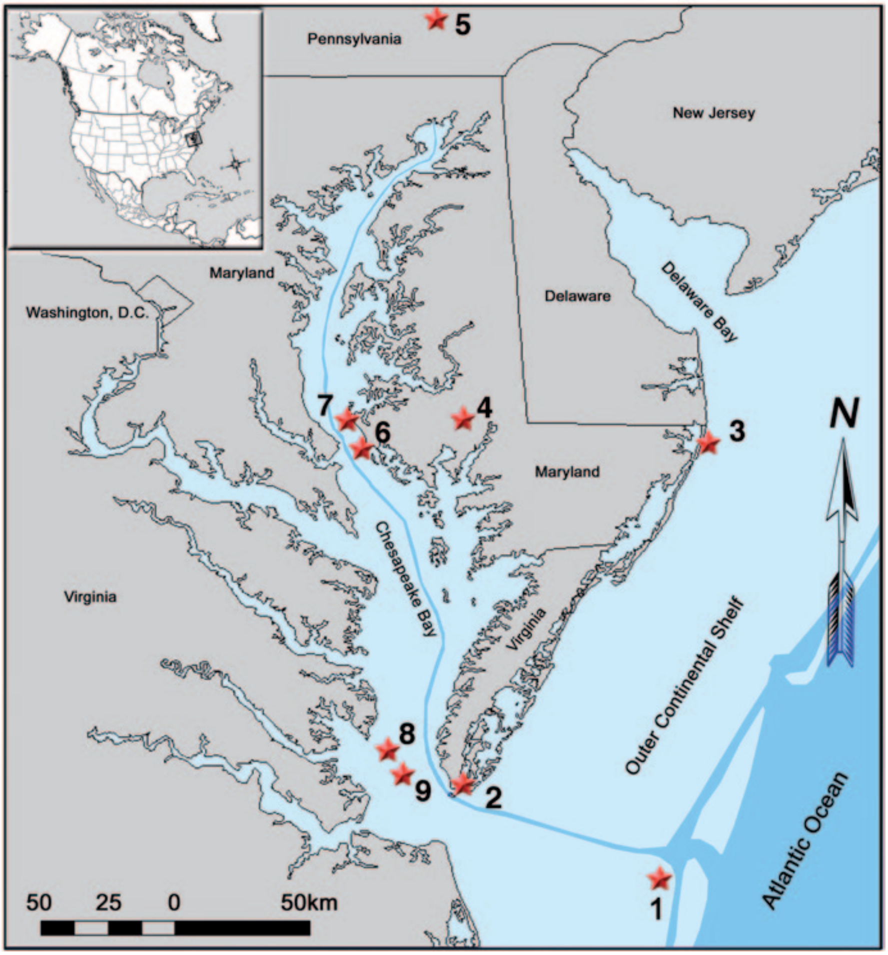

Fig. 5.9 Locations of Chesapeake Bay laurel leaf bifaces: *1* Cinmar site; *2* Hampton, Virginia; *3* Ocean City, Maryland; *4* Gore site; *5* Dauphin County, Pennsylvania; *6* Tar Bay, Maryland; *7* Taylor's Island, Maryland; *8* and *9* Mopjack, Bay Virginia

All but one of these bifaces were found within the Chesapeake Bay drainage system (Fig. 5.9). The single outlier came from sand dredged from offshore to replenish the beach at Ocean City, Maryland. Another was found while leveling a LGM sand dune (Fig. 5.9, 4) and a third was found eroding out of the LGM terrace adjacent to the Susquehanna River in Dauphin Co., Pennsylvania (Fig. 5.9, 5). A large quartzite biface in the Smithsonian's collection was found at Hampton, Virginia and donated to the museum in 1868 (Fig. 5.9, 2). The rest of these specimens were dredged from the Chesapeake Bay.

A specimen made of local quartzite was dredged from the shallow water between Tar Bay and Punch Island Creek off Dorchester County, Maryland (Fig. 5.10c). This

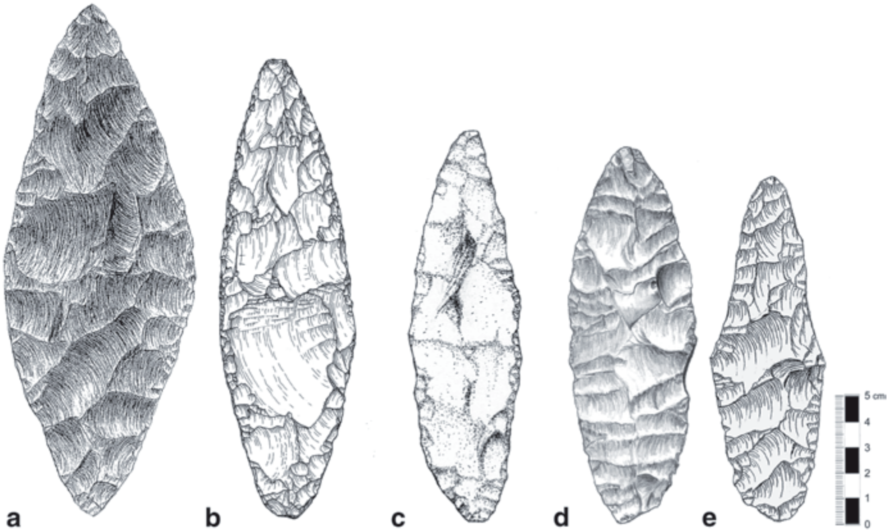

Fig. 5.10 Laurel leaf bifaces from underwater contexts. **a** Mopjake Bay. **b** Cinmar. **c** Heavily tumbled biface from Tar Bay. **d** Taylor's Island. **e** Heavily resharpened knife from Mopjack Bay

specimen was at one time in the near shore zone and is an example of damage seen on artifacts that have been heavily tumbled by "swash and berm action." Another specimen (Fig. 5.10d) was found within a drowned upland landscape underneath a thick covering of tidal marsh peat on the west side of Taylor's Island, in Dorchester County, Maryland. The knife is made of jasper; however, because it was sulfidized in the tidal marsh, it is highly stained, preventing identification of the source material. A large knife (Fig. 5.10a) made of quartzite was dredged from the bottom of Mopjack Bay near Norfolk, Virginia. Use-wear studies suggest that it was not hafted, but rather it was hand-held. A heavily resharpened biface (Fig. 5.10e), was also dredged from Mopjack Bay. Like the Cinmar biface, this tool was made of banded rhyolite and was used as a hafted knife.

It is important that these specimens were found in circumstances indicating that they were used and lost on the now-submerged continental shelf or the adjacent lowlands along the LGM Susquehanna River channel. It is also evident that they were all heavy-duty tools; likely used for butchering larger animals such as mastodons rather than smaller fauna.

If people settled eastern North America sometime between 23,000 and 15,000 years ago, why has this earlier archaeological record been so elusive? Perhaps one reason is that the initial population of Paleolithic people favored the rich diversity of the terrestrial and aquatic habitats of the now-submerged Continental margins and adjacent major drowned river systems. As these coastal ecosystems shifted westward due to rapidly rising sea levels approximately 14,500 years ago and as the human population increased, settlement accelerated into the upland interior, whose archaeological record is not buried as it is on the inundated coastal plain.

It is important to note that the manufacturing technology used to produce the Chesapeake Bay bifaces and the tool types themselves reflect the same technology as that used by the Solutrean people of southwestern Europe during the LGM (Stanford and Bradley 2012). Although more evidence is needed, it is not beyond the realm of possibility to hypothesize that this early settlement of the East Coast of North America resulted from a European Paleolithic maritime tradition. There is little question that the Cinmar discovery indicates that exciting new chapters in the story of Paleolithic people will be uncovered as archaeologists continue to investigate the continental shelves of oceans worldwide (Earlandson 2001). (Note: Funding has been obtained to conduct remote sensing survey of the area of sea floor noted by Capt. Shawn during the summer of 2013).

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References

Belknap, D. & Kraft, J. C. (1977). Holocene sea level changes and coastal stratigraphic units on the northwest flank of the Baltimore Canyon trough geosyncline. *Journal of Sedimentary Petrology, 47*(2), 610–629.

Bonder, G. H. (2001). *Metarhyolite use during the Transitional Archaic in Eastern North America*. Paper presented at the 66th Annual Meeting of the Society for American Archaeology in New Orleans, Louisiana, April 2001.

Clark, P., Dyke, A., Shakun, J., Carlson, A., Clark, J., Wohifarth, B., Mitrovica, C., Hostetler, S. & McCabe, A. (2009). The last glacial maximum. *Science, 325,* 710–714.

Earlandson, J. (2001). The archaeology of aquatic adaptations: paradigms for a new millennium. *Journal of Archaeological Research, 9,* 287–350.

Edwards, R. L., & Emery, K. O. (1977). Man on the continental shelf. In W. S. Newman & B. Salwen (Eds.), Amerinds and their Paleoenvironments in Northeastern North America. *Annals of the New York Academy of Science, 228,* 35.

Edwards, R. L., & Merrill, L. (1977). Reconstruction of the continental shelf areas of eastern North America for the times 9,500 B.P. and 12,500 B.P. *Archaeology of Eastern North America, 5,* 1.

Emery, K. O., & Edwards, R. L. (1966). Archaeological potential of the Atlantic continental shelf. *American Antiquity, 31,* 733.

Emery, K. O., Wigley, R., Barlett, A., Meyer, R., & Barghoorn, E. (1967). Freshwater peat on the continental shelf. *Science, 158,* 1301–1307.

Fanning, D. S., Rabenhorst, M. C., Balduff, D. M., Wagner, D. P., Orr, R. S., & Zurheide, P. K. (2010). An acid sulfate perspective on landscape/seascape soil mineralogy in the US Middle Atlantic region, *Geoderma, 154,* 457–464.

Faure, H., Walter, R. & Grant, D. (2002). The coastal oasis: Ice age springs on emerged continental shelves. *Global and Planetary Change, 33,* 47–56.

Glascock, M. D., Braswell, G. E. & Cobean, R. H. (1998). A systematic approach to obsidian source characterization. In M. S. Shackley (Ed.), *Archaeological obsidian studies: Method and theory* (pp. 15–65). New York: Plenum.

Grosman, L., Sharon, G., Goldman-Neuman, Y., Smikt O., & Smiansky, U. (2011). Studying post depositional damage on Acheulian bifaces using 3-D scanning. *Journal of Human Evolution, 60,* 398–406.

Holmes, W. H. (1897). *Stone implements of the Potomac-Chesapeake tidewater province*. Fifteenth annual report of the Bureau of American Ethnology. pp. 3–152.

Kay, M. (1996). Microwear analysis of some clovis and experimental chipped stonetools. In G. H. Odell (Ed.), *Stone tools: Theoretical insights into human prehistory* (pp. 315–344). New York: Plenum.

Kay, M. (1998). Scratchin' the surface: Stone artifact microwear evaluation. In M. B. Collins (Ed.), *Wilson Leonard: An 11,000-year archeological record of hunter-gatherers in central Texas. Volume III: Artifacts and special artifact studies* (pp. 743–794). Austin: Texas Archeological Research Laboratory, University of Texas at Austin and Archeology Studies Program, Report 10, Texas Department of Transportation Environmental Affairs Division Studies in Archeology 31.

Kraft, J. C., Belknap, D. F., & Kayan, I. (1983). Potentials of discovery of human occupation sites on the continental shelves and near shore coastal zone. In G. H. Odell (Ed.), *Quaternary coastlines and marine archaeology* (pp. 87–120). New York: Academic.

Lowery, D. (2003). *A landscape sculpted by wind and water: Archaeological and geomorphological investigations at the upper ridge site (44NH440) on Mockhorn Island in Northampton County, Virginia*. Manuscript on file at the Virginia Department of Historic Resources, Richmond, VA.

Lowery, D. (2008). *Archaeological survey of the Chesapeake Bay shorelines associated with Mathews County Virginia: An erosion threat study*. Survey and Planning Report Series. Virginia Department of Historic Resources, Richmond, VA.

Lowery, D., & Wagner, D. (2012). Geochemical impacts to prehistoric iron-rich siliceous artifacts in the nearshore coastal zone, *Journal of Archaeological Science, 39,* 690–697.

Lowery, D., O'Neal, M., Wah, J., Wagner, D., & Stanford, D. (2010). Late Pleistocene upland stratigraphy of the western Delmarva Peninsula. *Quaternary Science Review, 29,* 1472–1480.

Mallinson, D., Riggs, S., Robert Thieler, E., Culver, S., Farrell, K., Foster, D., Corbett, D., Horton, B., & Wehmiller, J. (2005). Late neogene and quaternary evolution of the Northern Albermarle Embayment, *Marine Geology, 217,* 97–117.

Milliman, J. & Emery, K. (1968). Sea levels during the past 35,000 years. *Science, 162,* 1121–1123.

Nikitina, D. L., Pizzuto, J. E., Schwimmer, R. A., & Ramsey, K. W. (2000). An updated Holocene sea-level curve for the Delaware coast. *Marine Geolology, 171,* 7–20.

Oldale, R., Colman, S., & Jones, G. (1993). Radiocarbon ages from two submerged strandline features in the western Gulf of Maine and a sea-level curve for the Northeastern Massachusetts coastal region. *Quaternary Research, 40,* 38–45.

Saunders, J. (1977). Late Pleistocene vertebrates of the western Ozark Highland, Missouri. *Illinois State Museum Reports of Investigations, 33,* 1–118.

Shea, J. (1999). Artifact abrasion, fluvial processes and "living floors" from the Early Paleolithic Site of 'Ubeidiya (Jordan Valley, Israel). *Geoarchaeology, 14,* 191–207.

Speakman, R. J., Glascock, M. D., Tykot, R. H., Descantes, C. H., Thatcher, J. J., & Skinner, C. E. (2007). Selected applications of laser ablation ICP-MS to archaeological research. In M. D. Glascock, R. J. Speakman, & R. S. Popelka-Filcoff (Eds.), *Archaeological chemistry: Analytical methods and archaeological interpretation, ACS Symposium Series Series 968* (pp. 275–296). Washington, DC: American Chemical Society.

Stafford, T., Jr., Hare, P., Currie, L., Jull, A., & Donahue, D. (1991). Acceleratoar radiocarbon dating at the molecular level. *Journal of Archaeological Sciences, 18,* 35–72.

Stanford, D., & Bradley, B. (2012). *Across Atlantic ice: The origin of America's Clovis culture*. Berkeley: University of California Press.

Stewart, R. M. (1984). South Mountain (meta) rhyolite: A perspective on prehistoric trade and exchange in the Middle Atlantic Region. In J. F. Custer (Ed.), *Prehistoric lithic exchange systems in the Middle Atlantic Region, monograph 3* (pp. 1–13). Newark: Center for Archaeological Research.

Stewart, R. M. (1987). Rhyolite quarry and quarry-related sites in Maryland and Pennsylvania. *Archaeology of Eastern North America, 15,* 47.

Waters, M., & Stafford, T. Jr. (2007). Redefining the age of Clovis: Implications for the peopling of the Americas. *Science, 315,* 1122–1126.

Weaver, A. J., Saenko, O., Clark, P. U., & Mitrovica, J. X. (2003). Meltwater pulse 1A from Antarctica as a trigger of the Bolling-Allerod warm interval. *Science, 299,* 1709–1713.

Whitmore, F., Emery, K., Cooke, H., & Swift, D. (1967). Elephant teeth from the Atlantic continental shelf. *Science, 156,* 1477–1481.