GEOARCHAEOLOGICAL CONSIDERATION OF THE RYAN-HARLEY SITE (8JE1004) IN THE WACISSA RIVER, NORTHERN FORIDA

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The inundated Ryan-Harley archaeology site (8Je-1004) is located in a swamp forest dissected by channels of the spring-fed Wacissa River. It is thought to represent an undisturbed Middle Paleoindian site placed in time from ~10,900 ^{14}C yr BP to ~10,500 ^{14}C yr BP (Anderson et al. 1996; Goodyear 1999; Dunbar 2002). Distribution and taphonomic analyses of the artifacts and vertebrate faunal remains recovered from the Suwannee point level suggest the artifact assemblage, including the faunal remains, represent an archaeological site component that remains relatively intact since its time of deposition. Additional conformation beyond the artifact suite is also necessary. To accomplish this, granulometric analyses of unconsolidated sediment samples were performed. Samples were collected from and immediately above and below the artifact horizon. Arithmetic probability plots of grain-size distributions suggest that most but not all of the sandy sediments were originally transported and deposited by fluvial processes. The artifact assemblage, faunal remains, and fine fraction eolian sand recovered from the site were deposited subsequent to the fluvial conditions. The granulometric analysis as well as other lines of evidence indicate the Suwannee point level at the Ryan-Harley site is essentially intact with little or no post-depositional reworking.

Key Words: sedimentology; Suwannee point; Paleoindian; Florida; late Pleistocene

INTRODUCTION

The Wacissa River is unusual because its base flow is maintained by artesian discharge from the Floridan aquifer system. The Wacissa River originates from several headsprings and then flows south through flat swampy terrain before its junction with the lower Aucilla River in multiple confluence areas. In contrast to the deep, often underground or entrenched surface channels of the Aucilla River, the Wacissa River basin is shallow and broad. Both river systems drain through and across karstic terrain. The Wacissa River is noted for having a varied channel system including sections dominated by one or two wide, shallow channels as well as sections dominated by numerous, small, braided channels (Yon 1966). Because of its low gradient (from headwater to sea level the difference in elevation is less than six meters), the Wacissa River is a relatively low energy stream with low erosive potential and transport competence. This is an important distinction since a braided channel system usually brings to mind desert-like arroyos or glacial-type outwash terrain and aggressive erosion. This is not the case with the Wacissa River, which occupies a swampy basin 1.5 to 5 km wide by 24 km long and does not have a succession of down-cut river terraces (Yon 1966). The Wacissa is classified as a calcareous stream with a flow predominantly sustained by relatively cool and clear spring water (Nordlie 1991:401-402). Nevertheless, erosion does take place in focused areas where, for one reason or another, the flow dynamics change and down cutting occurs in newly rerouted rivulets, or in blowouts of existing channels.

The Ryan-Harley site is located adjacent to a mostly sediment filled, Pleistocene paleo-channel that has not been fully mapped but appears to have once flowed in a southeasterly path. An extant Holocene channel has cut through and exposed the west side of the Ryan-Harley site. The active channel flows in a southerly direction and has exposed a small section of the paleo-channel just downstream from the Suwannee point level of the Ryan-Harley site.

The Ryan-Harley site is thought to represent a post-Clovis, Suwannee point campsite now located about

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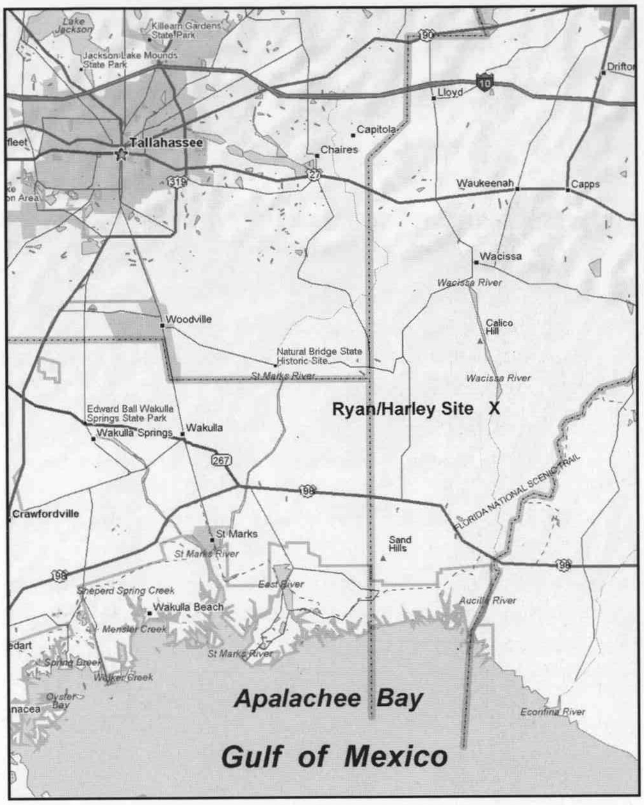


Figure 1. Location map of the Ryan-Harley site (8Je-1004).

one meter below the present low water stage of the Wacissa River (Fig. 1). The site is important because bone as well as stone artifacts have been preserved (Fig. 2). Attempts to radiocarbon date the site have thus far failed because associated charcoal has not been found, and organic silts have replaced the collagen content of the bone samples submitted for evaluation. Two radiocarbon dates on oxidized roots provide evidence that the site's Holocene inundation took place about 4,500 years ago and since that time botanical remains have been preserved, most notably the roots and rootlets of plants that invaded the sediment levels. Subsequent to Holocene inundation, roots that penetrated the Suwannee Point stratum represent a postdepositional invasion into the Suwannee and other levels of the site. It should also be mentioned that whatever potential bioturbation from plant growth might have occurred at the site, it did not cause the Suwannee artifacts to drift and become incorporated into the levels above or below the Suwannee point level.

Concerns relating to site integrity and formational processes (Schiffer 1996), particularly as they relate to American Paleoindian sites (e.g., Hibben1941; Haynes & Agogino 1986) are well documented. Multiple lines of evidence are needed to show site integrity, particularly when dealing with fluvially deposited sands that include artifact assemblages, like Ryan-Harley. In this paper we present archaeological, paleontological, and geological evidence of the site's formation and subsequent preservation. We believe that this evidence suggests that the Ryan-Harley site represents a single component Suwannee site that has remained undisturbed until its recent exposure due to modern erosion.

The artifacts and fossils from the Suwannee point level are contained within fluvial and eolian sand deposits. The eolian sand is indicative of the site's subaerial exposure around the time when the Suwannee artifacts were being incorporated in the fluvially deposited, point bar sand. Subsequent to the human activity that resulted in the archaeological deposit, additional eolian sand built up and covered the artifact bearing level. The occurrence of artifact assemblages in point bar sand deposits has been documented elsewhere in the southeastern United States. A primary cause of vertical artifact displacement in site accumulations on point bar sand is attributed to human trampling at occupation sites (Brooks & Sassaman 1990). The distribution of artifacts throughout the 10-15 cm-thick Suwannee point level appears to reflect similar site formational processes.

The purpose of this work is to identify the significance of cultural and natural processes that have taken place in, above, and below the Suwannee point level at the Ryan-Harley site. Although the area of test excavations was confined to a relatively small seven square meter area threatened by erosion (Fig. 3), we believe that it is significant to report because it represents the first Suwannee point site with good bone preservation discovered in the southeastern United States. The significance of the stone tools and preserved faunal bone assemblage has been reported elsewhere (Dunbar et al. in press; Dunbar & Vojnovski in press).

The Suwannee point level of the Ryan-Harley site is located in a quartz sand-dominated point bar deposit about 10-15 cm thick. The Suwannee point level consists of unconsolidated sands that many Florida archaeologists would find similar to upland sandy settings. The only unfamiliar aspects are that the site is inundated and, as a result, numerous Holocene roots and rootlets are preserved in the deposit. A finer-grained, more coherent sediment level lies below the Suwannee point level. It did not contain artifacts. An organic-rich sequence

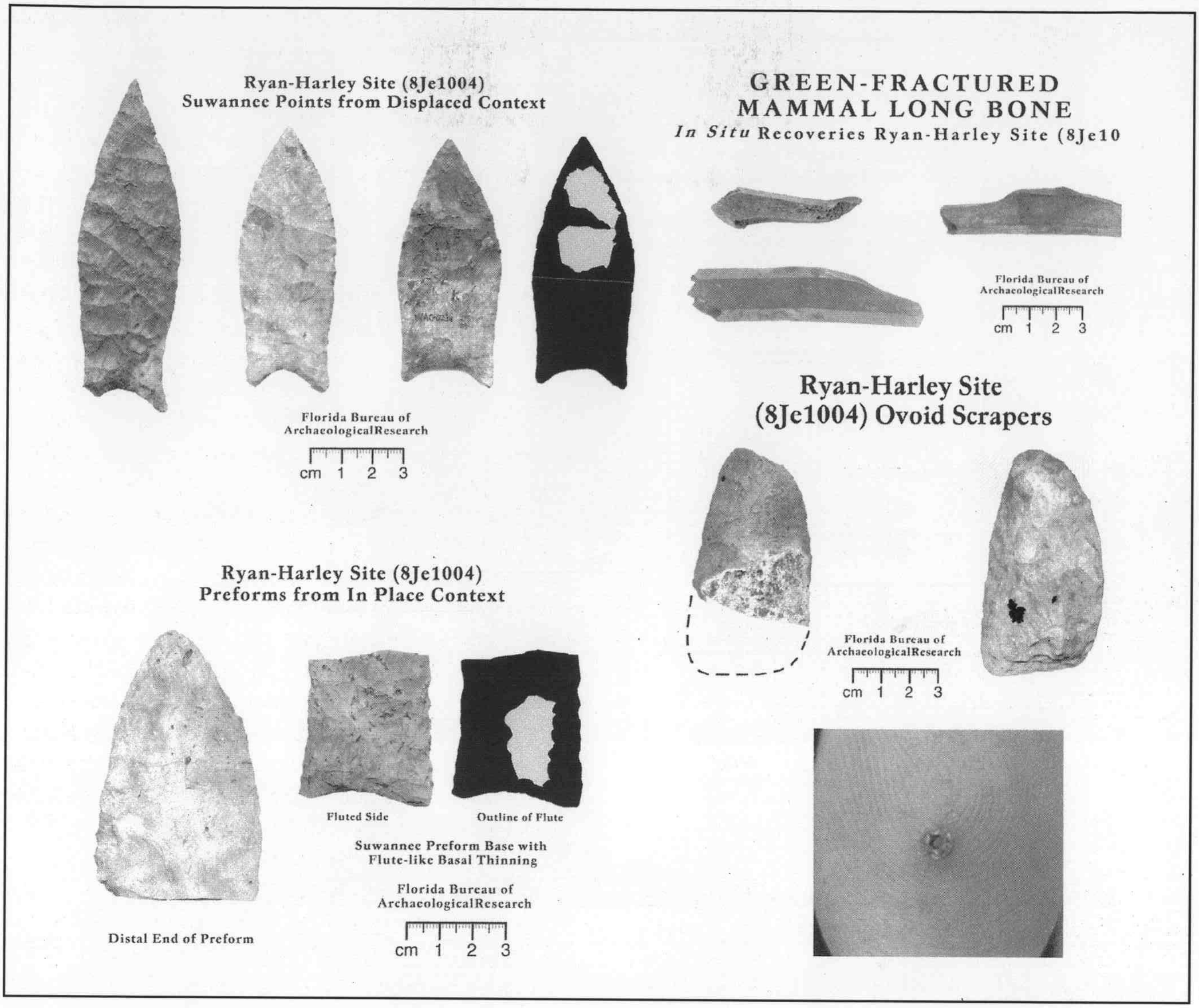


Figure 2. Bone fragments and Suwannee stone tools recovered from the Ryan-Harley site. Size range of artifacts was over two orders of magnitude. For instance, the bead shown in the lower right-hand inset has a diameter of 2.5 mm.

about 1 m thick rests above the Suwannee Point level. The base of the organic-rich level is sandy. This three-part stratigraphic section at the Ryan-Harley site is the primary focus of this chapter as are the pieces of evidence indicative of the agencies responsible for their formation. It is also important to consider in less detail the site's broader stratigraphic sequence. Thus we will also consider two horizontally divided aspects of the stratigraphy separately: 1) those associated with the adjacent paleo-river channel that does not include the Suwannee point level, and 2) those associated with the paleo-riverbank that includes the Suwannee point level.

PALEO-CHANNEL AND PALEO-RIVERBANK STRATIGRAPHY

Stratigraphic observations made along erosional cuts in the modern channel from controlled test units and vibracores indicate there is a difference between the sections observed in the paleo-river channel area versus that observed in the paleo-riverbank area. There is an approximately 3.5 m elevation difference between the top of the bedrock in the paleo-riverbank area compared to the top of the bedrock in the bottom of the paleo-river channel. The bottom of the paleo-river channel is ca. 1.2 m below current sea level compared to the elevation

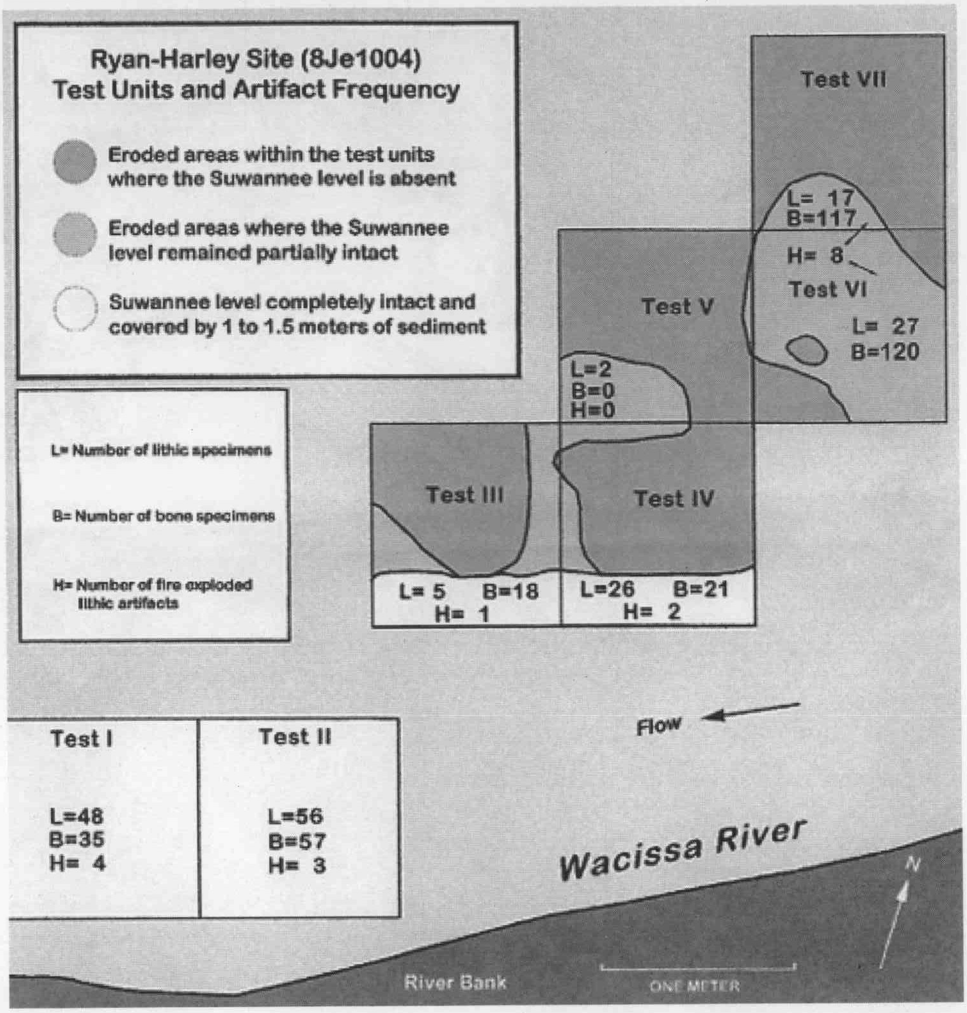


Figure 3. Ryan-Harley site test units with artifact frequencies.

of the Suwannee point level, which rests above bedrock at ca. 2.4 m above seal level.

Paleo-Channel Deposits

Two important stratigraphic sequences occupy the paleo-river channel. The lower, older sequence consists of lenses or beds of sand and freshwater shell marl. The higher, younger sequence consists primarily of channel-fill organic peat with sand stringers toward the bottom. Where these sequences remain intact they form a sediment column about 3.5 m thick. The upper peat is at least 2 m thick.

Stratigraphic information from the paleo-river channel was collected in the center of the extant channel (Fig. 4) where Holocene fluvial conditions exposed the older sequence and on the river's west margin near vibracore C3-98 where a complete section of the paleo-river channel sediments revealed both the older and younger sequences. In the river channel, the older sequence consists of ca. 40 cm of sand underlain by ca. 40 cm of white, freshwater shell marl. Below the shell marl there is ca. 55 cm of gray, sticky clay with limestone boulders in some areas of the test unit, and bedrock in other areas of the test unit. Farther west, a complete section of the paleo-river channel sediments revealed a slightly different sequence in the older section. The section near vibra-core C3-98 revealed a level of sand above shell marl. Below the shell marl there was another level of sand above bedrock. The gray clay level encountered in the center of the channel appears to represent a filled solution feature in the limestone bedrock that may or may not be related to the fluvial deposits. The lower sand level near vibra-core C3-98 is believed to represent sand channel lag deposits.

The freshwater shell horizon is of interest because the species of mollusks and other animal remains provide insight to the area's paleoecology and deposition as well as having modern environmental analogs in other sections of the Wacissa River today. Eight species of mollusk, one turtle, and one bony fish were identified in a sample taken from the site (Table 1). Most of the mollusk species in the horizon are generalists that prefer oligotrophic (well oxygenated) habitats, but can stand some siltation and acid-water turbidity. *Spilochlamys conica* (Thompson 1968), *Amnicola dalli dalli* (Pilsbry & Beacher 1892), and *Campeloma* sp. strictly require pristine habitats that would be characteristic of clear-water spring runs, in which the others would also thrive (K. Auffenberg pers. comm.). It seems very likely that the environment in which these mollusks lived was a spring run, very much like the present day Wacissa River. The presence of *Terrapene carolina* (Agassiz 1857) and the small bony fish in the horizon is also consistent with such an hypothesis.

Wide channel sections of the Wacissa River such as the channel at Goose Pasture represent a modern environmental analog (Fig. 5). Clear spring water flows through wide, open channel sections lush in aquatic vegetation and slow-moving water. This is in stark contrast to the numerous, much smaller but more abundant channels in the swamp forest sections of the Wacissa River. It is in the wide sections of the river in slower flowing,

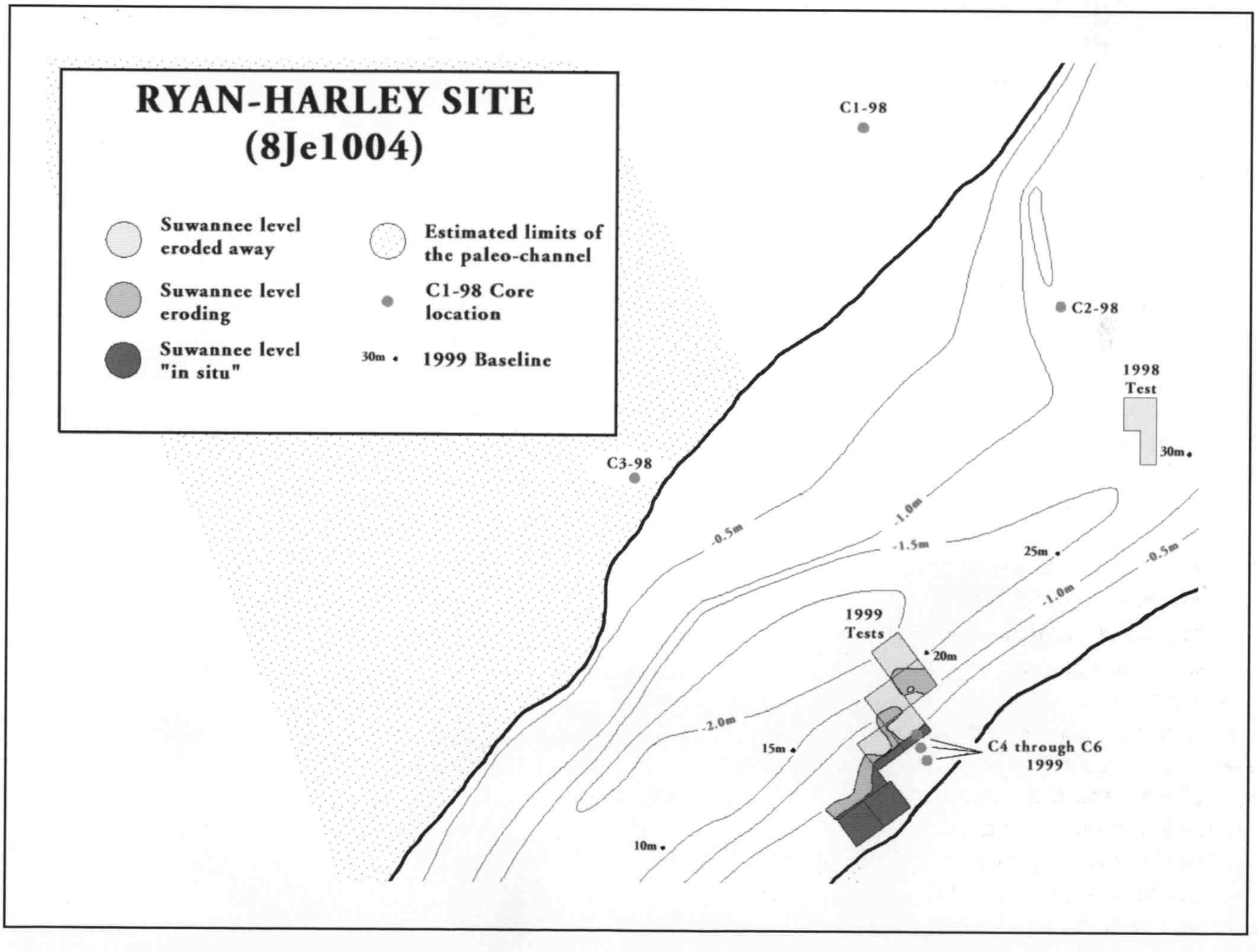


Figure 4. Site map of the Ryan-Harley site showing test units and vibra-core locations.

Table 1. Partial species list based on one sample of the freshwater shell marl at Ryan-Harley (8Je-1004).

MOLLUSCA: GASTROPODA
FAMILY HYDROBIIDAE
Littoridinops monroensis (Frauenfeld, 1863)
Spilochlamys conica (Thompson, 1968)
Amnicola dalli dalli (Pilsbry and Beacher, 1892)
FAMILY PLANORBIDAE
Planorbella sp.
FAMILY PLEUROCERIDAE
Elimia floridensis (Reeve, 1860)
FAMILY VIVIPARIDAE
Viviparus georgianus (Lea, 1834)
*Campeloma sp.*MOLLUSCA: BIVALVIA
FAMILY UNIONIDAE
CHORDATA: VERTEBRATA
CLASS REPTILLA
FAMILY EMYDIDAE
Terrapene carolina (Agassiz, 1857)
CLASS OSTEICHTHYES

backwater areas where abundant aquatic grass beds support large communities of gastropods. They occupy a variety of niches throughout the water column including clinging to grass blades and plant stems, or occupying the river bottom sediments. When they die, their calcareous shells sink to the bottom, and gradually accumulate as a species rich layer of shells.

The Ryan-Harley site shell layer is composed of differentially sized particles ranging from clay-sized calcium carbonate sediment to pebble-sized gastropods (Fig. 6). No exact particle size percentages have yet been determined. The majority of shell material is composed of broken fragments of varying size and most mollusk species are represented by various growth stages. All vertebrate fossil material is black and well mineralized. Vertebrate material appears to be relatively uncommon, yet it is easy to pick out due to its black color contrasted with the whitish shell marl.

There are at least four possible reasons why the gastropod shells in the Ryan-Harley shell marl layer may have become fragmented. The first relates to the acid breakdown of the calcareous shells. The Wacissa River is almost entirely springfed, but some blackwater creeks charged with tannic acids feed into the system, especially during wet seasons. Normally, the pH of spring water issuing from the Wacissa head springs is slightly basic, ranging from 7.4 to 8.0 (Scott et al. 2002). However, when the river turns black, the accompanying acidification may dissolve and leach out calcium carbonate from the shells, weakening certain areas until breakageoccurs. A second potential reason is fluvial action sufficient to result in their breakage. This seems unlikely because unconsolidated clay and silt-sized particles in the shell bed would have been transported away. If such an accumulation of shells had resulted due to fluvial deposition, a wider variety of other materials with similar transpo-depositional characteristics would be expected to occur in the sediment. Also, because most of the gastropods in the sample exhibited eroded apices, which represent the natural deterioration of the oldest part of the animal's shell during life, it appears that fluvial taphonomy did not take place. A third possible cause of fragmentation is simply the weight of the overlying sediment through time, but this seems unlikely because the shell marl layer was only 2 to 3 meters deep in the stratigraphic column. The fourth and most likely reason for shell breakage is the mollusk-crushing loggerhead musk turtle (*Sternotherus minor*) and centrarchid fishes

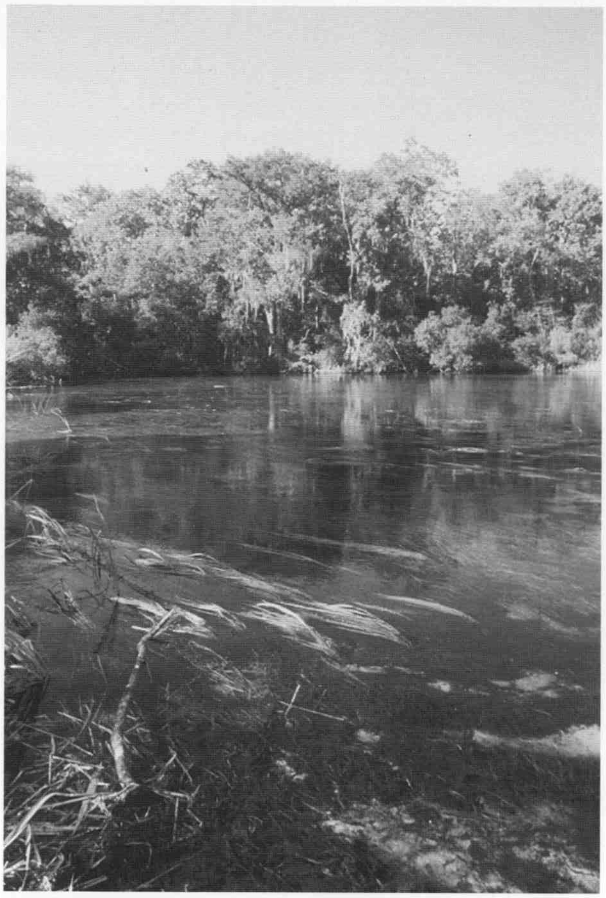


Figure 5. The Wacissa River at Goose Pasture showing modern depositional analog to the freshwater shell marl.

that feed on snails. Populations of these turtles (Ashton & Ashton 1981) and fish are abundant in the Wacissa River today. It is reasonable to assume that they were similarly abundant during the latest Pleistocene and early Holocene.

Another important consideration is the geographic range of the molluscan fauna. To date, there are no references that cover the entire state of Florida; those available cover only parts of the state or parts of the fauna (Clench & Turner 1956; Burch 1982; Thompson 1984). Seven of the mollusks recovered from the shell layer are extant in the Wacissa River, with the exception of the Banded Mystery snail, *Viviparus georgianus* (Lea 1834). The distribution of *V. georgianus* in Florida is from Palm Beach County north and west to the Steinhatchee River, which is almost the entire peninsula. Its range in the Panhandle is disjunct, including portions of the Choctawhatchee River, Apalachicola River, and Suwannee River (Thompson 1984). Interestingly, there is a gap in its modern day distribution located in Florida's Big Bend region, which includes the Aucilla and Wacissa Rivers. To date, no living specimens of *V. georgianus* have been collected in the Aucilla River drainage, despite many collecting efforts. Populations of *V. georgianus* are highly variable, and some researchers recognize certain of its variants as distinct species (Katoh & Foltz 1994). *Terrapene carolina* ranges widespread throughout the eastern United States with highly variable populations (Conant & Collins 1998), and is common in the Aucilla River drainage today. This terrestrial turtle species also spends some time in the water. It is not uncommon to see it foraging on the bottoms of ponds, puddles, or streams (Bartlett & Bartlett 1999).

Sediment above the shell marl includes lenses of channel lag sand, and sand components of uncertain depositional agencies. Only one diagnostic artifact originated from this sand sequence but its occurrence is important as a time marker. An Early Archaic, Bolen Bev-

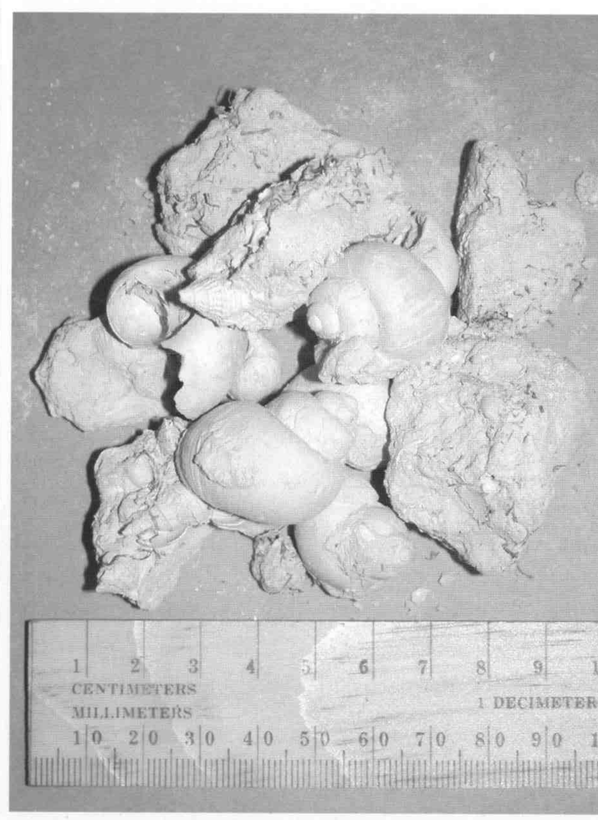


Figure 6. Fresh-water shell marl sample from the Ryan-Harley site.

eled point was recovered adjacent to vibra-core C3-98 from the upper sand level. The Bolen point displayed a patina indicating that it had been exposed to episodes of wet and dry conditions. The Bolen point came from an area of the test unit were the sand was capped by the younger peat sediment sequence.

Tree root casts were recovered in the area of vibra-core C3-98. A number of root casts were identified but all organic material in the casts had completely oxidized away. The root casts consisted of friable, cemented sand on and near the surface of the sand bed(s). The absence of preserved organic remains suggests the paleo-river channel was subaerially exposed.

The patinated Bolen point and the root casts provide evidence that the paleo-river channel went dry sometime during or after Bolen time. Bolen Beveled side-notched points have been dated in context elsewhere from ~10,000 ^{14}C yr BP to ~9,500 ^{14}C yr BP (Dunbar 2002), a time range that can be applied here as a possible relative date for the onset of the dry interval occurrence. Two osteoderms of the extinct 'giant armadillo' (*Holmesina septentrionalis*) were also recovered from the sand bed(s), but are believed to represent a time when the paleo-river channel held water because their dark color indicates they had taken on a tannic stain. In contrast, *Holmesina* osteoderms collected on the surface of the Suwannee point level in the paleo-riverbank area were not darkly stained.

The upper sediment sequence of the paleo-river channel consisted primarily of peat-rich organic deposits. While profiling the current-cut face of the exposed peat sequence in the vicinity of vibra-core C3-98, a Kirk Stemmed point dislodged from a location that appeared to be near the bottom of the peat sequence. Kirk points have been dated elsewhere in Florida between 8,200 and 7,000 ^{14}C yr BP (Bullen 1975; Doran 2002). A Kirk point from the bottom of the peat sequence suggests the channel was inundated by that time, otherwise preservation of the peat would not have been possible. If this reconstruction is correct, the episode of dry paleo-river channel conditions should date prior to the Kirk point times and fall somewhere between 10,000 and 8,500 ^{14}C yr BP. The deposition of peat in the paleo-river channel also insinuates an interval of still or quite water deposition.

Paleo-Riverbank Deposits

The paleo-riverbank deposits differ in many ways from the paleo-river channel deposits, although the shell marl in the paleo-river channel has an upslope facies that partially underlies the top three levels of the riverbank sequence. At and just upland from the paleo-riverbank, the limestone bedrock becomes much shallower and the shell marl facies pinch out. The primary stratigraphic sequence in the paleo-riverbank area is a lower silty sand followed by the point bar deposits that contain the Suwannee point level followed by an upper level of organic-rich silts and sands. The Suwannee point level is in a 10- to 15-cm-thick silt-sand mixed with chert artifacts and bones.

The lower silty sand unit produced no artifacts. Compared to the Suwannee point level, the lower silty sand level is more cohesive and difficult to excavate. It is also the level most resistant to fluvial erosion. The level contained skeletal elements of an alligator (*Alligator mississippiensis*) all of which appeared to represent a very large adult, probably from a single individual.

The Suwannee point level is an unconsolidated sand unit in which artifacts as well as faunal remains were distributed throughout its vertical thickness. In deep sand settings, it is not unusual to find a former prehistoric activity surface dispersed within a vertical thickness. Due to the unconsolidated nature of alluvial sands and such activities as human trampling during site occupation, bioturbation and other factors, it is unlikely to have former prehistoric surfaces represented as thin stratigraphic levels (Brooks & Sassaman 1990). A distinguishing factor of the Ryan-Harley site is that the unconsolidated sand bed is only 10 cm to 15 cm thick, and the spread of the artifacts is confined within that thickness.

Rather than representing a natural accumulation, several lines of evidence suggested the Suwannee point level represented an uncontaminated Middle Paleoindian-aged accumulation of artifacts deposited as a result of human activity. These include:

1. The presence of small bones and fish scales. Such small items would have been the first materials transported away from the site had flowing water affected the deposit (Dodson 1973:15-19).

2. The horizontal distribution of artifacts from the intact Suwannee point level was not sorted. In contrast, a sample of lithic artifacts recovered from a displaced context would be sorted with the larger specimens remaining upstream and the smaller transported downstream. Due to the susceptibility of some specimens over others, fluvial sorting takes place when an assemblage of specimens is differentially dispersed downstream. Some specimens (generally larger-sized) may

have little if any downstream movement in a given fluvial environment while others may experience appreciable movement (generally smaller-sized) and still others may be destroyed as a result of being transported (Voorhies 1969; Behrensmeyer 1975; Behrensmeyer 1988; Hanson 1980). The general absence of size sorting is reflected by the occurrence of varied size, shape and density ranges of the stone and bone assemblage from the Suwannee point level.

3. In one test unit the tip and base of a Suwannee point were recovered from displaced context before excavation began. The tip and base fit together and represent another indication of the recent nature of erosion and the internal integrity of the uneroded portion of the site. Similarly, and perhaps more convincing, two articulated white-tailed deer vertebra were found in situ.

4. The Suwannee component exists throughout the 10- to 15-cm-thick sediment lens and appears to be a midden-like, not a deflated lag-like, deposit.

5. One of the surface-collected waisted Suwannee points and the Suwannee preform recovered from context at Ryan-Harley site display over-shot flaking and fluting, both of which are Clovis-like traits. The uniface tools recovered in context include a snub-nosed end scraper on a blade-flake, discoidal (turtleback) and ovate scrapers, and flake tools reminiscent of Clovis. In addition, the hafting end of an obliquely truncated, basally-roughened ivory shaft was recovered from displaced context. We believe the artifact assemblage from the Ryan-Harley site does not include Clovis artifacts; rather we believe it is a Suwannee assemblage with holdover Clovis-like traits. In addition, no artifacts suggestive of post Suwannee point age were recovered from the Suwannee Point level even though an Early Archaic Bolen point was recovered from the nearby paleo-river channel deposits.

6. Excavation of the Suwannee point level produced no marine or brackish water species. However, materials collected directly adjacent to the test units from displaced deposits produced mullet (*Mugil* spp.), hardhead catfish (*Arius felis*), and eagle ray (Myliobatidae). These are migratory marine, brackish, and freshwater species that are found in the Wacissa River today. However, it is unlikely they could have traveled from the late Pleistocene coastline that far inland. Remote sensing and bathymetric mapping of the sea floor offshore of the Aucilla River have shown that the paleo-channel of the Aucilla River in Apalachee Bay is a discontinuous network of isolated karst surface channels (Faught & Donoghue 1997), obstructions that also impeded migrations too far up river.

7. The wetland species recovered from the Suwannee point level are indicative of animals that prefer or require still-water habitats. "The environmental picture provided by the in situ faunal assemblage is that of a shallow, low energy freshwater stream or, perhaps, pond as a permanent, nearby water source.... All terrestrial mammals identified in the sample are known to frequent wetland habitats (horse, raccoon, muskrat, rabbit, mink, tapir, deer). The vast majority of reptiles, with the exception of the gopher tortoise, required an aquatic habitat. Fish species present prefer quiet or stagnant waters as habitat." (Dunbar et al. in press). Faunal remains recovered from displaced context adjacent to the test units included additional species that prefer flowing water environments and fluvial conditions such as those that exist today.

8. The chert artifacts from the Suwannee point level are patinated. This is indicative of one or more episodes of subaerial exposure. Subaerial exposure of sufficient duration to allow wet-dry cycles in terrestrial sediment columns to provide the environment is necessary for chert patination to take place.

Taken together, this evidence suggests the Suwannee artifacts accumulated when the Suwannee point level was subaerially exposed. However, there are certain relatively recent developed geologic procedures that can be employed to shed additional light on the character of the Ryan-Harley site.

SEDIMENTOLOGIC ANALYSES

Geological methods were employed to determine sedimentologic interpretations for samples collected at the Ryan-Harley archaeological site. One goals of a geologist is to reconstruct and identify environments of the past. Endeavors to do so have been proposed during the last century and have been met with considerable lack of success and skepticism (Tanner 1980). However, based on the analysis of some 11,000 sediment samples from many depositional environments, Tanner (1983, 1986, 1991; also Balsillie 1995) developed methodologies for identifying transportation-depositional environments, termed *transpo-depositional environ-*

ments.

The Wacissa River originates from and flows through the Woodville Karst Plain physiographic province. The headsprings of the river are located just south of the Cody Escarpment near the town of Wacissa, Florida. Tertiary limestones of the Suwannee Limestone (lower Oligocene) crop out or are near the surface in the region, and numerous karst features have developed including sinkholes, natural bridges, disappearing rivers, and springs. The Suwannee Limestone is a moldic packstone to grainstone containing little or no quartz sand. Several dolomitic sections are recognized. Post-Suwannee sediments, probably of Pleistocene age, overlie the Suwannee Limestone. It is from these sediments that the artifacts were recovered. Sediment lithologies range from sands with some silt and clay to almost purely organic peats; freshwater mollusk deposits are common.

The complex and rapidly changing facies of these sediments makes regional correlation difficult, however, as will be discussed later, tentative correlation can be made between a regional event stratigraphy developed for the Page-Ladson site (8JE591) to the stratigraphic sequence at the Ryan-Harley site. Admittedly, the absence of radiometric dates from the Ryan-Harley site makes the correlation difficult, however, the variation of changing Pleistocene climates as reflected in the highly dated event stratigraphy is sufficient to allow for such a correlation (Dunbar 2002).

Sea level during the time of site occupation was about 40 m lower than at present (Balsillie & Donoghue 2004), which means that the shoreline was ca. 122 km seaward of the present day shoreline. As the Ryan-Harley site lies 17 km upland of the present day shore, the site during occupation was about 139 km from the Gulf of Mexico shoreline. For the purposes of granulometric analysis, we can, therefore, rule out that the site was located in a littoral or lagoon setting. Because it is located along the present day Wacissa River, it might seem reasonable to assume it occupied a fluvial setting. It could, however, have been a lake (lacustrine) environment which if large enough would have waves and, therefore, a littoral signature; or it could have been a dune (eolian) environment; glacial agencies can be ruled out. It is the aim of this work to unequivocally identify the type of environment of the site at the time of occupation, and to determine if, following occupation, the site was subject to reworking by natural processes.

Field Sampling

Investigation of the Ryan-Harley archaeological site required special conditions. Site investigation and sampling could only be accomplished subaqueously using SCUBA equipment. While the depth was not great (about one meter), SCUBA afforded the opportunity for continuity in exposure inspection and sampling by multiple investigators. Even so, one should be able to appreciate the difficulties in obtaining lamina samples under such sampling conditions. Successful quantitative granulometric results critically depend on specific field sampling protocols. Principal among such protocols are lamina sampling, field sample size, and multiple sampling.

Lamina Sampling. The desired field sample for unconsolidated sediments is the *lamina sample* (Balsillie 1995). This is the *sedimentation unit* of Otto (1938:575) defined as "... that thickness of sediment which is deposited under essentially constant conditions". Apfel (1938:67) used the terminology *phase sampling* in which phase is defined as "... deposition during a single fluctuation in the competency of the transporting agency" (see also Jopling 1964). The *lamina sample*, *sedimentation unit*, or *phase sample* represents a narrowly defined event. For example, they are not deposited by a flood persisting over a period of several weeks, but more nearly are deposited by single energy pulses repeatedly occurring during the event. Just what a *lamina sample*, *sedimentation unit*, or *phase sample* is in terms of a recognizable item defined by physical principles is not known, short of being parallel to the bedding plane. But we do recognize them to some general extent, and regardless of the unknowns one should strive to collect *lamina samples* (Balsillie 1995, 2003). Identification of laminae in the field can be obvious to problematic. Spraying an exposure surface with a mist of water can, in instances, be helpful with identifying bedding details, then disappearing upon evaporation. While laminae vary in thickness, one is generally safe in sampling along (i.e., parallel to) a bedding plane for a thickness of about 0.01 m.

Field Sample Size. Field sediment samples are required to be of a size specifically suited for the type of quantitative analysis to be conducted in the laboratory. The ideal field sample size is 45 g (± 10 g) for sieving laboratory analysis, or 90 g (± 20 g) for samples that require splitting.

For some inexplicable reason this sample-size request is all-too-often not followed, and requires special discussion here. If one requires more, the simple solution is to collect multiple 45 g samples. If one takes large samples, it is a signal that the field worker has not been careful in following a stratigraphically consistent bedding plane sampling strategy. The problem becomes exacerbated because large samples may represent multiple transpo-depositional agencies which, upon transport in a vehicle (auto, boat, aircraft), they can become resorted and not represent their original transpo-depositonal signatures. If, upon laboratory preparation, the sample will require splitting for purposes of required archival or potential litigation, it will introduce error (Wentworth 1926; Swineford & Swineford 1968; Sanford & Swift 1971), each split resulting in about a five percent error (Tanner & Emmerling 1974; Socci & Tanner 1980). Only one split is permissible.

Multiple Sampling. Multiple sampling of the same bedding plane is preferable to a single sample for identifying the transpo-depositional signature of the bedding plane. Such an approach more nearly assures quantitative results. Five to eight bedding plane or laminae samples (i.e., sample suites) are sufficient to ensure confident results. Three or four samples are probably adequate to yield reliable results, but more samples are desirable.

For the Ryan-Harley site, six samples were readily obtained from the artifact horizon. Four samples were forthcoming immediately below the artifact horizon. However, the sediment lens immediately above the artifact horizon was comprised primarily of organic matter, and only three samples contained enough sand-sized material to allow for granulometric analysis.

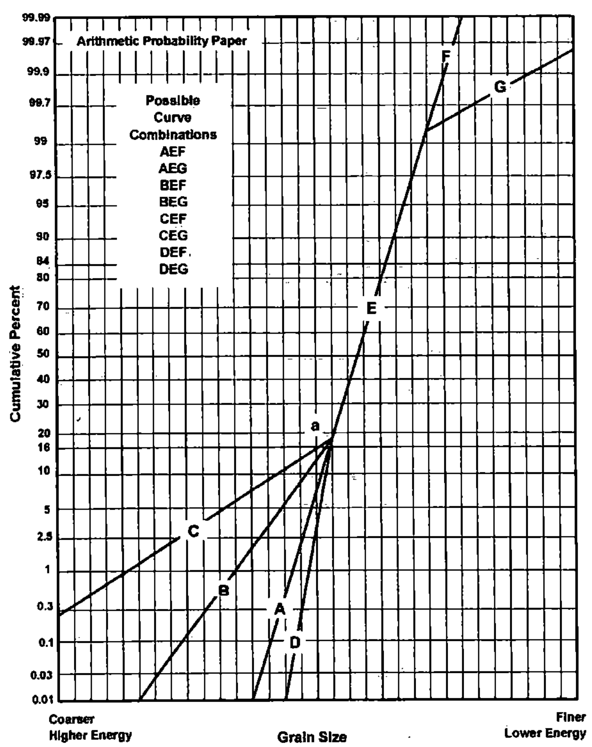
ANALYTICAL PROCEDURES

Sample Preparation and Analysis. Thirteen field samples were procured at the Ryan-Harley archaeological site. Six samples were taken within the artifact horizon (Je1004-FS1), three were procured immediately above (ca. 0.075 m), and four were taken immediately below (ca. 0.075 m) the artifact horizon.

Laboratory procedures used in this work are those specified by W. F. Tanner (Balsillie 1995). Samples were washed and wet sieved using a 4.0 phi sieve to obtain the fine fraction (i.e., silt and clay fraction). The fine fraction was processed by pipette analysis to determine grain size according to procedures of Galehouse (1971) and Folk (1974). Organic matter was removed using 30% H_2O_2 according to the methodology of Ingram (1971) and Jackson et al. (1949). The granule and sand fractions were dried and processed by Rotap-type sieving techniques using 8-inch diameter half-height sieves and Meinzer II fixed amplitude sieve shakers (Balsillie & Dabous 2003). Samples were sieved for 30-minutes with ¼-phi sieve intervals using a nest ranging in size from -2.0 phi to 4.0 phi.

Gaussian Applications. Standard methods of quantifying sediment textural data employ statistical measures (mean, standard deviation, skewness, kurtosis), grain-size distribution diagrams, and frequency and cumulative frequency probability plots. Probability considerations, whether one is dealing with sample suites or single samples, are based on the underlying concept that sediments conform to the "Normal" or Gaussian density distribution function. Results from statistical application of the Gaussian distribution are best plotted using arithmetic probability paper (APP). The usefulness of APP is, among informed practitioners, of unequaled practical importance when compared to other plotting options (Balsillie et al. 2002). The graph paper has one arithmetic axis that represents quantifiable data (e.g., sediment grain size) plotted against the cumulative percent occurrence (or cumulative probability), which is a nonlinear axis. Typically, the arithmetic axis is the horizontal axis representing grain size. The nonlinear (Gaussian) axis is the vertical axis and represents the cumulative percent weight from the sieve fractions. The cumulative probability distribution of the paper has commonly been termed the "normal" distribution. It should not be so designated, however, because "normal" is applied in too many applications. It should properly be referred to as the Gaussian distribution or Gaussian probability density distribution (GPDD). APP, constructed so that the ogive (S-shaped curve on arithmetic paper; see Balsillie et al. 2002, for description) plots as a straight line, was developed in 1913 by Hazen (1914), and is acknowledged as a milestone in statistical graphic applications (Friendly & Denis 2001). There are three fundamental properties of the GPPD that when plotted on APP require understanding.

First, if the quantified data, in general, conform to the Gaussian distribution, any one sample shall, if it is precisely Gaussian, plot as a straight line on APP. Second, are the natural data of any one sample precisely equivalent to the GPDD? Most are not, nor would we wish them so, for it is the deviation from the Gaussian that tells us something about the sample. This is especially true for sediment grain-size distributions. Third, natural data plotted on APP may, in many applications, be made up of several straight-line segments. These segments are often attributable to some identifiable natural cause or process. Tanner (1991) found that the geometry of straight-line segments for sediment distributions can definitively identify whether the latest trans-



SEGMENT	DESCRIPTION OF GRANULOMETRIC INTERPRETATION
AEF	The Gaussian distribution. Plots as a straight line on arithmetic probability paper.
B	Indicates that the operating transp-depositional force element is wave activity; point a, relative to segment E, is termed the ***surf-break***. This slope, which is relatively gentle, represents beach sand. The higher the slope of segment B, the higher the wave energy. Note that for sand-sized material, the surf-break normally appears for low- to moderate-energy wave climates. For high-energy waves, point a moves off the graph (to the bottom) and segment B disappears (i.e., the wave energy is over-powering even to the coarsest sand-sized sediment fraction available (Savage, 1958; Balsillie, 1999).
D	Indicates eolian processes; point a is termed, relative to segment E, the ***eolian hump***.
C	Represents fluvial energy; has a steep slope, the greater the slope the higher the energy level. This segment is termed the ***fluvial coarse tail***. It may also represent a pebble beach, or sand transported and depositied by tidal currents.
E	Central segment of the sample distribution.
G	Represents the low energy tail termed the ***settling tail*** and, if present, may indicate lowering of energy for the total distribution or component distributions of the coarser sediments.

Figure 7. Transpo-depositional interpretation of sediments using arithmetic probability paper (Balsillie 1995).

portation-depositional (termed "transpo-depositional) history of the sediment sample was due to eolian, littoral, fluvial, settling processes, etc., or even combinations of processes (Balsillie 1995). Arithmetic-arithmetic, logarithmic-logarithmic, arithmetic-logarithmic (semi-logarithmic), and other plotting media have been used to display analytical GPDD results. The above three properties will invariably not be evident, however, except where APP is used.

In recent years advancements have been made in sedimentology, which identify the last agencies involved in the transportation and deposition of sand-sized sediments (Tanner 1986, 1991; Balsillie 1995). We present here (Fig. 7) APP plots and straight-line analysis techniques for identifying transpo-depositional signatures of individual sediment samples. Bivariate plotting tools for sample suites (Tanner 1986, 19991; Balsillie 1995) are also used as an additional approach for determining transpo-depositional signatures of sample suites.

Results of Granulometric Analyses

Samples of the Ryan-Harley site contain appreciable quantities of organics (Table 2). Organics are of little significance from a granulometric point of view other than, perhaps, interfering with attaining a desirable field sample mass. Organic masses for the artifact horizon and immediately below the artifact horizon were tolerable at suite average of 5.58% and 1.89%, respectively. However, samples immediately above the artifact horizon had a significant suite average of 37.06% organics. This may be of importance as it relates to site stability, to be discussed latter.

Sample and suite statistics of the Ryan-Harley sediments are listed in Table 3. Granulometric interpretations for identifying environments of deposition are accomplished by analyzing single samples and sample suites using suite statistics. Suite statistics involve the determination of the mean of the means for a suite of samples, standard deviation of the means, skewness of the means, kurtosis of the means, and so forth for the all individual moment measures. The ramifications of suite statistics were detailed by Balsillie and Tanner (1999).

Ryan-Harley sediment samples are all very fine

Table 2. Sample mass and Wentworth (1922) fractions

Sample ID	Total Sample Mass (grams)	% Granule	% Sand	% Silt	% Clay	% Organics
		ARTIFACT HORIZON				
8Je1004-AH-1	44.553	0.76	93.18	2.24	3.82	1.41
8Je1004-AH-2	38.078	0.24	95.30	1.84	2.63	7.18
8Je1004-AH-3	28.044	0.21	92.48	2.85	4.46	5.87
8Je1004-AH-4	108.160	0.33	96.19	3.48		NA
8Je1004-AH-5	33.724	7.97	86.39	2.08	3.56	10.72
8Je1004-AH-6	39.952	0.79	94.71	1.63	2.88	2.70
		IMMEDIATELY ABOVE ARTIFACT HORIZON				
8Je1004-AAH-5	13.723	5.98	79.08	6.92	8.02	35.68
8Je1004-AAH-6	17.56	15.77	70.56	6.83	6.83	30.38
8Je1004-AAH-7	8.865	27.88	44.48	12.97	14.66	45.11
		IMMEDIATELY BELOW ARTIFACT HORIZON				
8Je1004-BAH-1	48.391	0.06	91.57	2.58	5.79	0.94
8Je1004-BAH-2	30.625	0.00	91.35	2.45	6.20	3.28
8Je1004-BAH-3	37.589	0.00	88.69	3.72	7.58	3.33
8Je1004-BAH-4	48.228	0.00	91.81	2.28	5.91	0.00

grained according to the Wentworth (1922) size scale. Suite statistics show sediments above and below the artifact horizon are finer grained than those in the artifact horizon (Table 3). Hence, while all samples reflect low energy transpo-depostional conditions, energy levels for the artifact horizon were slightly greater.

The fine-grained nature of samples is due, in part, to the appreciable amount (3.5% to 27.6% by weight) of fines (i.e., silts and clays) contained in the samples asserting, as shall be later quantified, certain transpo-depositional signatures. However, samples immediately above the artifact horizon contained 3.28 times more fine material than the artifact horizon. This too, may be of consequence in assessing stability of the artifact horizon.

We first analyzed each sample using Gaussian applications as illustrated by Figure 7. The methodology allows for the identification of six transpo-depositional agencies: fluvial, settling from water, tidal, littoral (waves), eolian, and glacial-fluvial. Following the ex-

Table 3. Sample and suite statistics for Ryan/Harley sediment

Sample I.D.	Mean m (phi)	Standard Deviation s (phi-units)	Relative Dispersion s/m	Skewness Sk	Kurtosis K	6th Moment Measure	Maximum Grain Size (phi)
SAMPLE STATISITICS: IMMEDIATELY ABOVE ARTIFACT HORIZON							
8Je1004-AH-5	4.2714	2.5133	0.6844[a]	1.5853	3.9045	19.794	0.875
8Je1004-AH-6	4.1807	2.2101	0.5837[a]	1.9157	5.2523	35.700	0.875
8Je1004-AH-7	5.7220	3.1657	1.1150[a]	0.5168	1.3837	2.254	0.375
SUITE STATISTICS: IMMEDIATELY ABOVE ARTIFACT HORIZON							
Mean	$m_m = 4.7247$	$m_s = 2.6297$	0.5566[b]	$m_{Sk} = 1.3393$	$m_K = 3.5135$	$m_{6MM} = 19.249$	$m_{maxd} = 0.7083$
Standard Deviation	$s_m = 0.8649$	$s_s = 0.4883$	0.5646[b]	$s_{Sk} = 0.7312$	$s_K = 1.9637$	$s_{6MM} = 16.730$	$s_{maxd} = 0.289$
Skewness	$Sk_m = 1.7106$	$Sk_s = 1.0117$	0.5914[b]	$Sk_{Sk} = -1.3427$	$Sk_K = -0.8605$	$Sk_{6MM} = -0.146$	$Sk_{maxd} = -1.732$
Kurtosis	NC	NC	NC	NC	NC	NC	NC
SAMPLE STATISITICS: ARTIFACT HORIZON							
8Je1004-AH-1	3.0965	0.9578	0.8934[a]	1.0331	7.6234	70.453	-0.875
8Je1004-AH-2	3.1761	1.3735	0.8762[a]	3.4910	18.6182	442.077	-0.875
8Je1004-AH-3	3.3942	1.6549	0.6481[a]	3.1429	12.8439	200.105	-0.675
8Je1004-AH-4	3.1664	1.0877	1.4618[a]	2.4165	16.0309	305.098	-2.185
8Je1004-AH-5	3.2718	1.5605	0.7049[a]	3.2895	14.7135	266.407	-0.625
8Je1004-AH-6	3.1857	1.3819	0.8089[a]	3.5724	18.7037	440.295	-0.875
SUITE STATISTICS: ARTIFACT HORIZON							
Mean	$m_m = 3.2151$	$m_s = 1.3361$	0.4156[b]	$m_{Sk} = 2.8242$	$m_K = 14.7556$	$m_{6MM} = 287.406$	$m_{maxd} = -1.016$
Standard Deviation	$s_m = 0.1040$	$s_s = 0.2684$	2.5803[b]	$s_{Sk} = 0.9692$	$s_K = 4.1631$	$s_{6MM} = 143.347$	$s_{maxd} = 0.582$
Skewness	$Sk_m = 1.0807$	$Sk_s = -0.3965$	-0.3668[b]	$Sk_{Sk} = -1.6363$	$Sk_K = -1.0334$	$Sk_{6MM} = -0.367$	$Sk_{maxd} = -2.245$
Kurtosis	$K_m = 1.1932$	$K_s = -1.2414$	-1.0404[b]	$K_{Sk} = 2.3876$	$K_K = 0.9022$	$K_{6MM} = -0.626$	$K_{maxd} = 5.268$
SAMPLE STATISITICS: IMMEDIATELY BELOW ARTIFACT HORIZON							
8Je1004-AH-1	3.5581	1.7379	0.5416[a]	3.0412	11.4655	155.261	-0.125
8Je1004-AH-2	3.6009	1.8094	0.5121[a]	2.9289	10.5292	130.069	-0.375
8Je1004-AH-3	3.7552	1.9756	0.6131[a]	2.5261	8.1954	80.655	-0.625
8Je1004-AH-4	3.5534	1.7477	0.5955[a]	3.0110	11.3634	152.283	-0.375
SUITE STATISTICS: IMMEDIATELY BELOW ARTIFACT HORIZON							
Mean	$m_m = 3.6169$	$m_s = 1.8177$	0.5025[b]	$m_{Sk} = 2.8768$	$m_K = 10.3884$	$m_{6MM} = 129.567$	$m_{maxd} = -0.375$
Standard Deviation	$s_m = 0.0946$	$s_s = 0.1100$	1.1618[b]	$s_{Sk} = 0.2386$	$s_K = 1.5209$	$s_{6MM} = 34.491$	$s_{maxd} = 0.204$
Skewness	$Sk_m = 1.7156$	$Sk_s = 1.5499$	0.9034[b]	$Sk_{Sk} = -1.7740$	$Sk_K = -1.5854$	$Sk_{6MM} = -1.435$	$Sk_{maxd} = 0.000$
Kurtosis	$K_m = 2.8730$	$K_s = 2.1631$	0.7529[b]	$K_{Sk} = 3.1593$	$K_K = 2.3081$	$K_{6MM} = 1.635$	$K_{maxd} = 1.500$

NC: could not be calculated; MM = moment measure.

The relative dispersion is the standard deviation divided by the mean.

[a]calculated where original midpoint grain-size data were in millimeters.

[b]calculated from phi suite means, and suite standard deviations in phi-units.

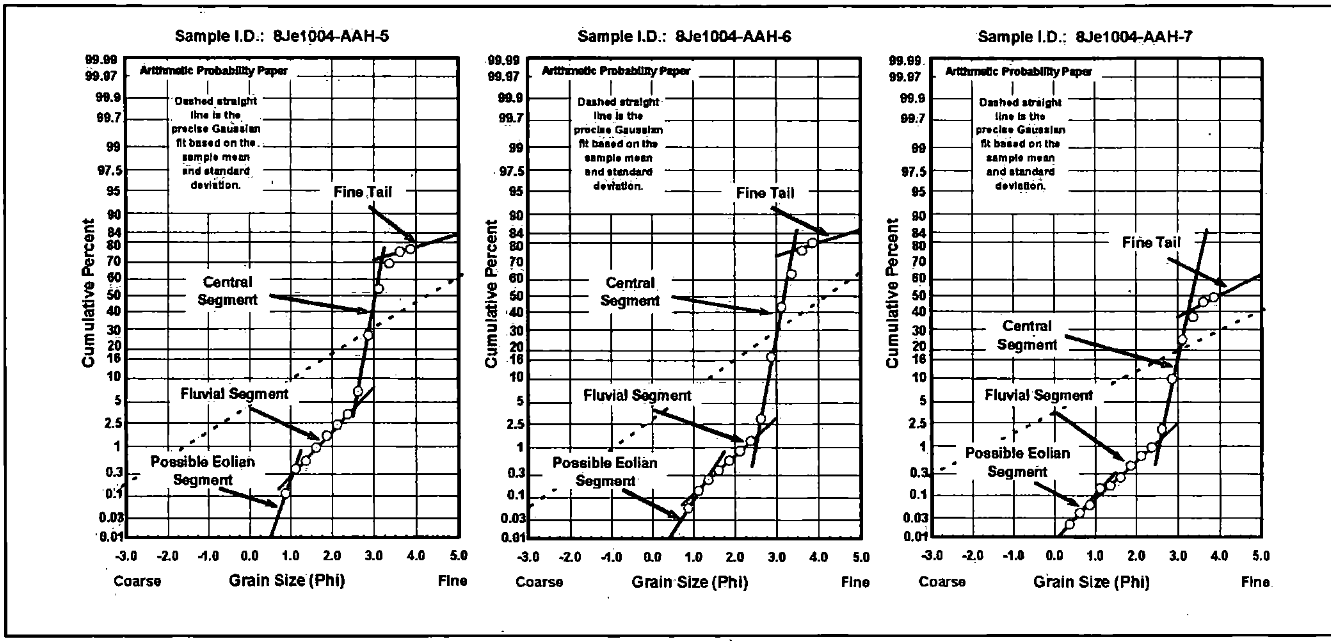


Figure 8. Arithmetic probability plots of unconsolidated sediment samples from immediately above the artifact horizon of the Ryan/Harley archaeological site. Granulometric interpretations are based on distribution line-segment analyses (Balsillie 1995, 2002; Balsillie et al. 2002).

ample of Figure 7, analytical results for samples taken immediately above the artifact horizon are plotted in Figure 8, those for the artifact horizon in Figure 9, and those for samples from immediately below the artifact horizon in Figure 10. Tallied results for the three Ryan-Harley horizons sampled are listed in Table 4. The results unanimously indicate that all three horizons were deposited by fluvial processes and settling from water conditions, the latter indicating low energy transpo-depositional agencies. Between 50% and 83% of the samples, depending on the horizon suite (Table 4), identified possible eolian signatures. If post-depositional reworking of sediments by a fluvial agency were to have occurred, the eolian signature would have been lost. The most logical explanation is that the sediments were deposited in a fluvial setting during the rainy season and decorated by eolian processes during the dry season when water levels were lower.

Now, if one can specify a relationship between grain size (d) and stream flow rate at the bed (v) we can evaluate kinetic energy based solely on sediment grain size. While several methodologies are available, we have selected Shields' method (Vanoni 1924; Shields 1936; Graf & Aczrglu 1966; White 1970; Blatt et al. 1970:102-103) relating particle diameter and bed flow speed required to induce sediment entrainment. It was found that energy levels for all horizons investigated were low, with that of the artifact horizon about half an order of magnitude larger than for sediments immediately underlying the artifact horizon. Sediments immediately above the artifact horizon had energy levels less than that for the artifact horizon by about 1.5 orders of magnitude. The latter, then, is consistent with a conclusion that the artifact horizon is intact and not reworked.

Suite statistics can also be assessed using bivariate plotting tools for determination of transpo-depositional environments as developed by Tanner (1986, 1991; also Balsillie 1995). Three such tools are used here. The first is the tail-of-fines plot. This is a special case in which the suite means and suite standard deviations of that portion of samples finer than 4.0 phi (i.e., silt and clay) are determined and plotted. The results are plotted in Figure 11, indicating that all samples are fluvial and associated with a closed basin, where the closed basin indicated settling of fines in still water.

The second tool, the relative dispersion plot is given by Figure 12. The relative dispersion (also known as the coefficient of variation) is the standard deviation divided by the mean. This parameter is used to compare variability between data sets even if there are large differences in magnitudes of both the means and standard deviations (Rees 1995). The relative dispersion plot applies only where $\mu_\mu = 1.0$ phi. Figure 12 shows that sample suites representing the three Ryan-Harley horizons all indicate settling from water due to still water conditions.

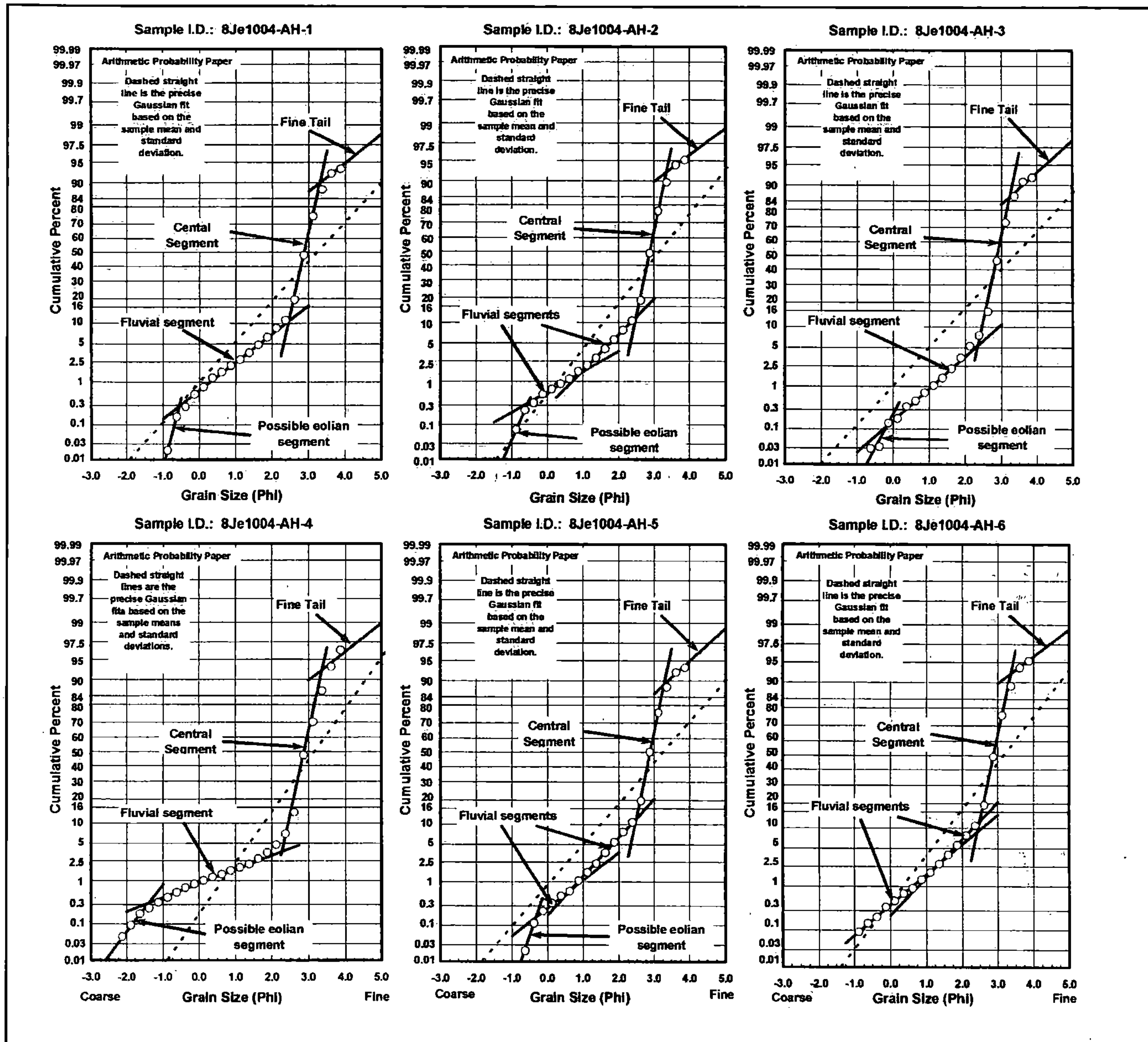


Figure 9. Arithmetic probability plots of unconsolidated sediment samples from the artifact horizon of the Ryan/Harley archaeological site. Granulometric interpretations are based on distribution line-segment analyses (Balsillie 1995, 2002; Balsillie et al. 2002).

The third bivariate plot (Fig. 13) contains the suite mean kurtosis, μ_K, versus the square root of the suite mean of the 6th moment measure, $(\mu_{6MM})^{1/2}$ developed by Tanner (Balsillie 1995). Suite statistics for all three horizons plot as fluvial deposition.

Hence, both individual sample arithmetic probability paper analyses and bivariate plotting tools using suite statistics are in agreement. Coarse tails of all individual sample plots distinctively and definitively indicate fluvial transpo-depositional signatures. Likewise, fine tails of all samples contain sufficient amounts of silt and clay to indicate that hydraulic conditions were calm enough to allow for settling of fine particulate matter. Hence, we can conclude that the site can be characterized as a low-energy fluvial setting, probably a point-bar type of physiography, a conclusion also reached by the three bivariate suite statistics plotting tools. A considerable number of samples also indicate eolian influence. This makes some sense, since the point bar would be an exposed feature during relatively low water conditions and

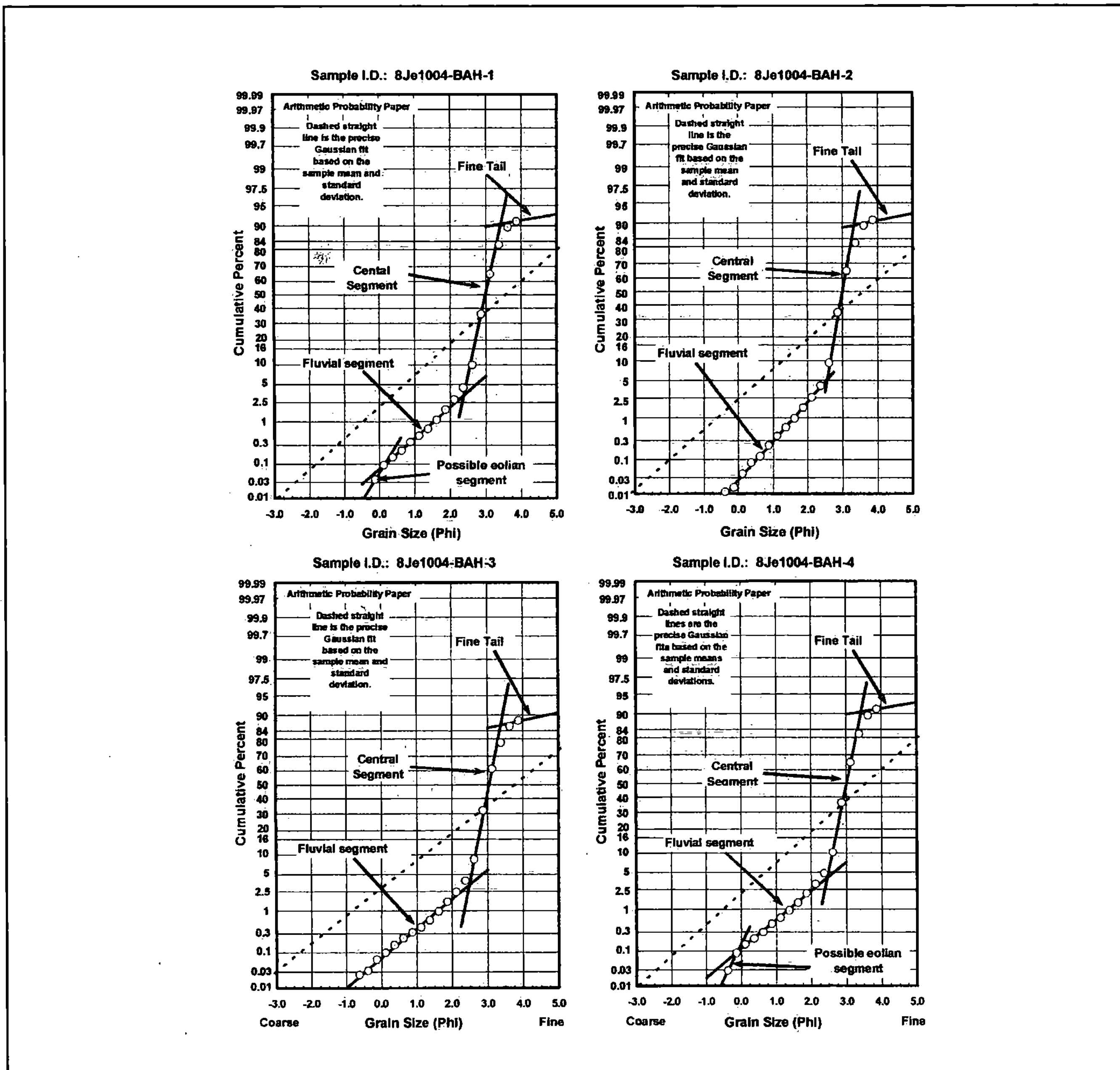


Figure 10. Arithmetic probability plots of unconsolidated sediment samples from immediately below the artifact horizon of the Ryan/Harley archaeological site. Granulometric interpretations are based on distribution line-segment analyses (Balsillie 1995, 2002; Balsillie et al. 2002).

subject to at least some eolian reworking.

POST-DEPOSITIONAL REWORKING

Whether or not natural processes subsequent to occupation have disturbed an archaeological site is often a matter difficult to prove. Resolution of the vicissitudes of natural forces on sedimentary environments are particularly difficult to discern, because of the large range in energy levels that can occur due to such events as floods and storms.

When faced with a problem whose solution is confounding or appears insurmountable, it is wise counsel that the problem solvers divide the problem into "smaller", more manageable problems for contemplation. We can divide the problem at hand at the Ryan-Harley site into two parts: 1) were the natural "ambient" sediment re-

Table 4. Number of samples and percentages of transpo-depositional agencies as identified in sample arithmetic probability plots for each sample suite.

Sampling Plane Suites	Fluvial	Settling	Tidal	Littoral	Eolian	Glacial
Above Artifact Horizon	3	3	0	0	2	0
	100%	100%	0%	0%	67%	0%
Artifact Horizon	6	6	0	0	5	0
	100%	100%	0%	0%	83%	0%
Below Artifact Horizon	4	4	0	0	2	0
	100%	100%	0%	0%	50%	0%

worked and/or 2) were the artifacts reworked?

As to the first issue, all samples represent granulometery of the artifact horizon minus any anthropomorphic objects and are, therefore, "ambient" natural samples. It is apparent from our analytical work that the major transpo-depositional signature of the ambient samples is low-energy fluvial in character. There is, however, another signature, that of some eolian reworking, that can have occurred only under subaerial, not subaqueous, conditions. It must, therefore, have happened *after* the last fluvial transpo-depositional episode. Any higher energy fluvial activity such as a flood would have destroyed the eolian signature and we can deduce with some considerable confidence, that the ambient deposit is intact. Moreover, it was found that energy levels above the artifact horizon were significantly less than for the artifact horizon. This, then, is consistent with a non-reworking signature of the artifact horizon. The amount of organic material in the artifact horizon and increased amount in the horizon above the artifact horizon is also consistent with in situ stabilization of the horizons through vegetative growth.

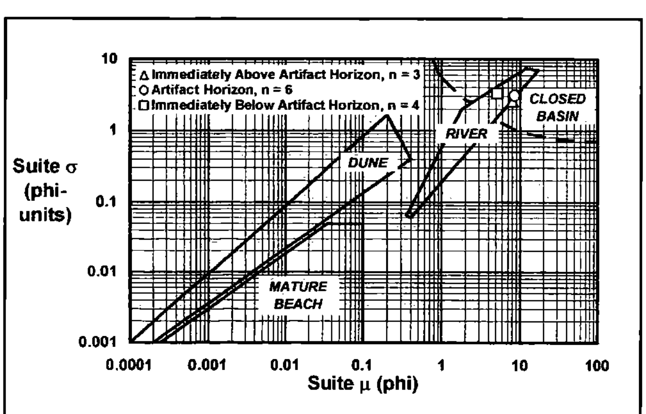


Figure 11. Tail-of-fines plot (Tanner 1991; Balsillie 1995).

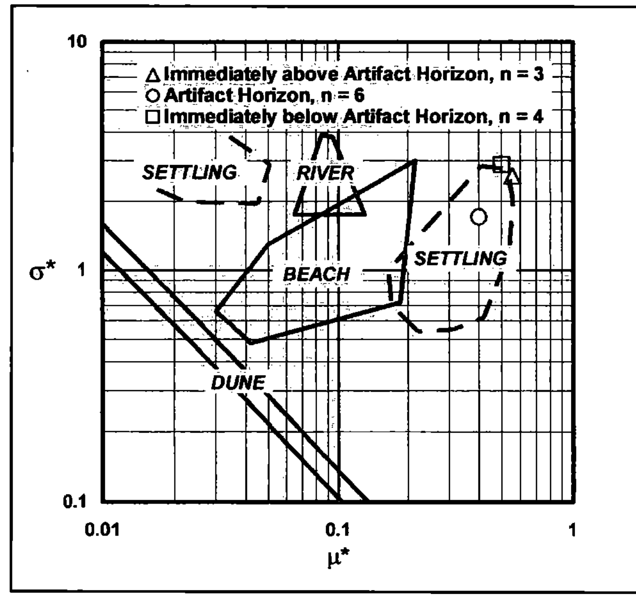


Figure 12. Relative dispersion plot (Tanner 1991; Balsillie 1995).

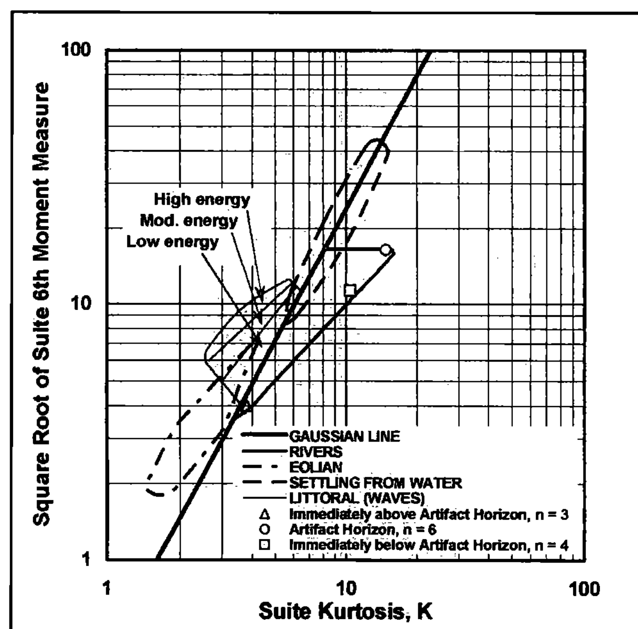


Figure 13. Suite mean kurtosis versus root suite mean 6th moment measure (Balsillie 1995).

The second part of the problem concerns the artifacts. In a seven square meter area, 193 artifacts were recovered totaling 1,390 kg in mass (Dunbar et al. in press). They included objects ranging in size and mass from fish scales, hunting points and tools, an articulated White-tailed deer (*Odocoileus virginianus)* vertebral

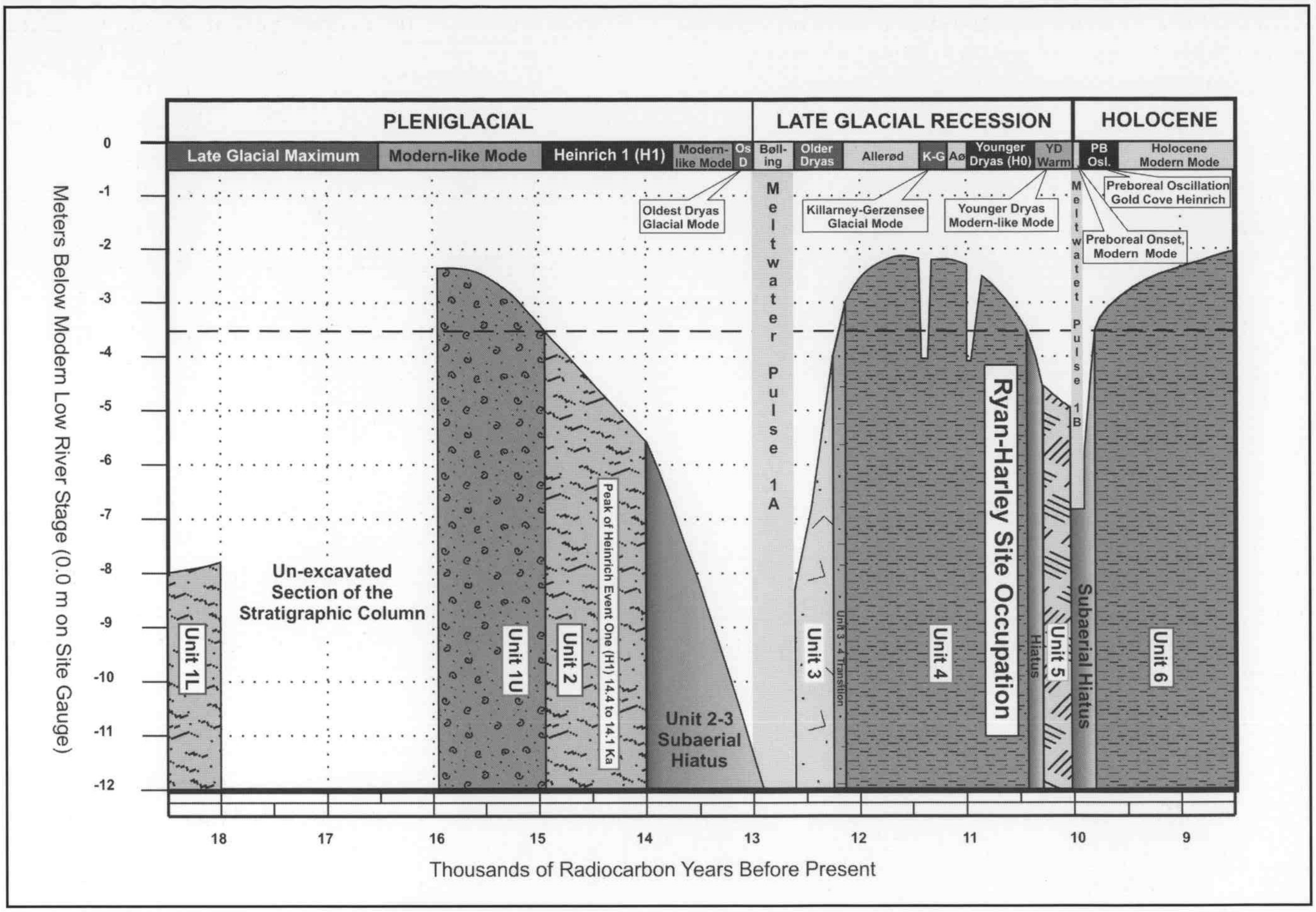


Figure 14. Stratigraphy and estimated water table stands from the Page-Ladson Site (8JE591).

segment, and a 0.13 m diameter chert nodule worked for hunting points. Fish scales have low mass density and are plate shaped, both of which makes them susceptible to transport, particularly by a fluvial agency. The 0.13 m diameter chert artifact would require very high flood-type energy levels to produce entrainment and transportation. Could the random assortment of artifacts have been eroded from an upstream locale and deposited as a point-bar deposit at the Ryan-Harley site? That is a possibility with the following exceptions. First, it is doubtful given the large range in mass densities and artifact sizes that they would all be deposited in the same point-bar locale based on competency requirements of a high-energy fluvial event required for transport. Second, granulometric techniques support the other observations mentioned in the "Paleo-river Bank Deposits" section above. Once, again, therefore, it is suggested that the Ryan-Harley site, to the extent sampled, has remained intact.

EVENT STRATIGRAPHIC CORRELATIONS

Because the preponderance of evidence indicates the Ryan-Harley site Suwannee point level is undisturbed and therefore represents a Middle Paleoindian archaeological site, it is appropriate to compare it with the North Florida event stratigraphy developed at the Page-Ladson site.

Earth scientists from Europe and America formed the INTegration of Ice-core, MArine and TErrestrial records (INTIMATE) Group. Among the proposals the INTIMATE Group has made are procedures and methodological guidelines for the interpretation of late Pleistocene proxy data (Björck et al. 1998; Walker et al. 1999; Walker et al. 2001; Lowe et al. 2001). The INTIMATE Group recognized the isotope record derived from the GRIP ss08c ice-core as the most fine-grained indicator of late glacial climatic change. As such, this Greenland ice-core record has been identified as a benchmark stratotype. Within the GRIP stratotype, several short-term climatic episodes are recognized and collectively represent an event stratigraphy. Because virtually all of the late glacial climatic shifts affected Europe and America, particularly along the Atlantic coastline, event stratigraphies promise to offer a means to correlate short-term events (100 to 1000 year periodicity) by absolute or relative means. The event stratigraphy developed at the Page-Ladson site was derived from a seven-meter plus stratigraphic column placed in time by 59 radiocarbon dates (Dunbar, 2002). The Page-Ladson stratigraphic column has seven different stratigraphic units interrupted by three hiatuses. The Page-Ladson stratigraphic units have been developed into a local, North Florida event stratigraphy that has been correlated to the GRIP stratotype and its event stratigraphy. Importantly, the Page-Ladson site event stratigraphy has also been correlated to late Pleistocene water table fluctuations (Fig. 14; Dunbar 2002).

To date there are only two radiocarbon dates obtained on samples from the Ryan-Harley site. Five samples of bone, four from extant species and one from an extinct species, were submitted for radiometric dating. However, all of the bone specimens had lost their collagen content and could not be dated. Thus, the Suwannee component has not been successfully dated even though two radiometric dates from oxidized roots recovered in and just above the artifact producing level yielded dates of 4,420 ± 60 yr BP (Beta 132151) and 4,590 ± 70 yr BP (Beta 123575). We believe these dates represent the approximate time of mid-Holocene inundation of the paleo-riverbank section of the site. After permanent inundation, further oxidation of Holocene plant materials stopped.

We next considered a four level, undated sequence of paleo-riverbank deposits at the Ryan-Harley site. The lowest level is the upslope facies of the shell marl. At the Page-Ladson site there were two late Pleistocene and one early Holocene episodes of near-present water table stands during which fluvial conditions prevailed. The earliest is most similar to the Ryan-Harley shell marl in that both have abundant freshwater mollusk remains. Actually there are numerous sequences of shell marl in the Aucilla River and its tributary the Wacissa River. All but two of the Aucilla River sequences remain undated. The Aucilla shell marls that have been dated are located in deep water (~ 6 m or more) in sediment-filled sinkholes (Page-Ladson and Aucilla 3E sites) where preserved botanical remains provided suitable radiometric samples. The full sequence of shell marl has not been fully penetrated in either of the dated sites. At the Page-Ladson site, the deepest part of the unit yielded a radiocarbon age of 15,390 ±120 ^{14}C yr BP (n=1, 18,389 Cal yr BP). The top of the sequence at the Page-Ladson site and Aucilla 3E yielded related dates with a pooled average of 15,166 ±157 ^{14}C yr BP (n=3, 18,131 Cal yr BP). The onset of shell marl deposition has not been determined, however the termination of shell marl deposition and the beginning of a different type of sedimentation dates to ca. 15,000 ^{14}C yr BP. Shell marl deposition took place during a modern-like climatic mode of the Pleniglacial and ended at the onset of the dramatic glacial cooling event known as Heinrich 1 (Dunbar 2002).

Just because the shell marl sequence at the Ryan-Harley site resembles the dated sequences from the Aucilla River does not mean it equates with the Aucilla sequence in time. Nevertheless there is only one other interval in the event stratigraphy when the water table was elevated to near modern levels. That took place during the middle Allerød through early Younger Dryas from ca. 12,300 to 10,400 ^{14}C yr BP (Dunbar 2002). This narrows the options if the shell marl level at the Ryan-Harley site dates to a time after the late glacial maximum. That issue remains unresolved at this point of the research. Assuming the shell marl is a postglacial maximum deposit, it is possible that it formed either during the modern-like mode of the Pleniglacial or during the middle Allerød fluvial settings.

Dates on the Allerød high water table episode come from Page-Ladson (Dunbar 2002) as well as the Little River Rapids site in the Aucilla River (Muniz 1998a-c). Estimated dates on this interval of fluvial conditions are placed from ca. 11,700 to 11,000 ^{14}C yr BP. From 11,000 to 9,000 ^{14}C yr BP there is a hiatus in the Little River sequence suggesting the water table had dropped and exposed part of the channel bottom (Muniz pers. comm.). At the Page-Ladson site fluvial conditions remained although somewhat attenuated. By 10,400 ^{14}C yr BP, the water table had dropped to a level that sustained still water or intermittently flowing water environments at the Page-Ladson site. Beginning at the Younger Dryas-Preboreal boundary at 10,000 ^{14}C yr BP, the water tables dropped dramatically, not only in North Florida but also in South Florida (Clausen et al. 1979; Dietrich et al. 1997). Water table elevations at the Page-Ladson as well as the Little Salt Springs sites are estimated to have reached as much as seven meters below the present level. In the southeastern United States this event is termed the Bolen Drought and was at its lowest between ca. 10,000 to 9,900 ^{14}C yr BP during the Preboreal onset. The severe conditions appear to have eased somewhat after 9,900 ^{14}C yr BP, however, inland water tables remained depressed until 8,500 ^{14}C yr BP when shallow lake basins in Florida began to permanently fill with water due to water table rise and noticeably moderate climatic conditions (Watts 1983).

Granulametric analyses indicate that fluvial deposition was followed by an interval of eolian deposition and subaerial exposure of the point bar (Suwannee point) level. Hence, the Suwannee point level was occupied by humans after the point bar deposits became subaerially exposed. The Suwannee artifact assemblage at the Ryan-Harley site is unique in that some of the Suwannee points and Suwannee stone tools have Clovis-like features. The Middle Paleoindian, Suwannee point tool tradition has been dated to ca. 10,900 10,500 ^{14}C yr BP and the occurrence of Clovis-like traits suggests the Suwannee assemblage at the Ryan-Harley sites dates to the early end of that timeframe. Therefore, it is reasonable to tentatively correlate the Suwannee point level to the earlier end of the Younger Dryas. As discussed earlier, the faunal assemblage from the site suggests that a low energy, wetland environment existed in the site area. No doubt, the nearest water source was the adjacent paleo-river channel with several other, more persistent, water sources located in nearby sinkholes and river channel sections.

The organic-rich silty sands that lie above the Suwannee point level appear to have continued to accumulate. The Bolen Drought at the Preboreal onset likely accounts for the isolated find of a patinated Bolen point and oxidized root casts in the paleo-river channel section of the site. Based on the event stratigraphy, the paleo-river channel at the Ryan-Harley site should have began going dry by ca. 10,400 ^{14}C yr BP and became dry by ca. 10,000 ^{14}C yr BP. Dry channel conditions probably lasted to about 9,000 ^{14}C yr BP. Depressed water tables after the Middle Paleoindian timeframe may be a reason why the Ryan-Harley site has yielded little evidence of subsequent Late Paleoindian or Early Archaic human activity.

Finally, the organic-rich paleo-riverbank level above the Suwannee point level likely experienced an accelerated rate of deposition after 4,500 ^{14}C yr BP when water tables reached near-modern level. Prior to that, the organic-rich fills in the paleo-river channel had begun to be deposited by 8,500 ^{14}C yr BP as a result of the first "permanent" water table rise in the Holocene.

CONCLUSIONS

Several lines of evidence including granulometric techniques for identifying environments of deposition indicate the Ryan-Harley site represents an important, undisturbed Middle Paleoindian site. While there can and probably should be additional archaeological and geoarchaeological testing at this site, it has already yielded sufficient information to merit regional if not national significance. It is, in all likelihood, the first Suwannee point site with both stone and bone preservation discovered in the southeastern United States. The site appears to be a campsite that has already provided a wide range of archaeological interpretation. Another important aspect of the site not previously mentioned is that it probably can be dated by OSL, reverse spin resonance and/or thermal luminescent techniques. Based on the amount and the location of recovery of heat exploded lithic artifacts, the site may still yield the remnants of an old fire hearth with preserved charcoal. In addition there appears to have been some headway toward being able to accurately date bone apatite. Should that develop the bone assemblage from the site could provide radiocarbon assays.

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