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A geoarchaeological evaluation of an early human burial from Brazoria County, Texas

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Abstract

The skeleton of a human adult female was excavated from alluvial sediments along the Gulf Coastal Plain of Texas. She was buried face down in an extended position with her hands crossed beneath the waist. Initial radiocarbon ages indicated that this skeleton dated to the late Pleistocene. Geoarchaeological and archaeological excavations at the site, coupled with new radiocarbon ages, amino acid compositional data, and an analysis of the previously reported radiocarbon ages obtained from the skeleton instead suggest a middle Holocene age for this burial.

Keywords: Texas; Human skeleton; Geoarchaeology

1. Introduction

At 41BO223 (also known as BZT-1), an archaeological site on the San Bernard Wildlife Refuge, Brazoria County, Texas, d'Aigle and Hryshechko (2002, 2003) reported the discovery of a human skeleton that they believe dated to the late Pleistocene. This discovery led to further archaeological and geoarchaeological investigations at this site and another nearby site designated 41BO215 (also known as BZT-2) (d'Aigle and Hryshechko, 2002) in May 2003. This new work was undertaken to define and correlate the stratigraphy at 41BO223 and 41BO215; date the stratigraphic sequence; determine the stratigraphic position of the human skeleton from 41BO223; determine the stratigraphic position of the shell midden at 41BO215; excavate, conserve, and analyze the skeleton at 41BO223; and determine the geological age of the skeleton. This paper presents the results of this investigation.

2. Background and history of archaeological investigations

The human skeletal remains found at 41BO223 were discovered by personnel of the Fish and Wildlife Services on the San Bernard Wildlife Refuge, Brazoria County, Texas, after the excavation of a drainage ditch in April 1999. Exposed in the sidewall of the ditch were fragments of the upper portion of a human skull. CRC, International Archaeology & Ecology was contracted to conduct an exploratory investigation of the remains (d'Aigle and Hryshechko, 2002). CRC personnel spent five days examining the site in the field in May and July 2001. During this time, the skull, mandible, and a few other bones were removed. In addition, a ground penetrating radar (GPR) survey of the area was undertaken to prospect for other possible human remains at the site. Geological studies, which included backhoe trenching and coring, were undertaken by two geologists, Howell and Moya (2002).

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Numerous analyses were conducted on the human bones and subsequent studies were made on sediments collected from the site. These analyses included: radiocarbon dating of four samples, the analysis of sediment and bone samples for ancient DNA, the analysis of sediment samples for human protein residues, the analysis of soil and sediment samples for texture and chemical composition, stable carbon isotope analysis of a tooth, and the examination of the human remains (d'Aigle and Hryshechko, 2002). In addition, d'Aigle and Hryshechko (2002) examined a shell midden (41BO215) located 66 m southwest of 41BO223.

Based on the field work and laboratory analyses, d'Aigle and Hryshechko (2002, 2003) confirmed that the remains were human and suggested that the skeleton may have been oriented in a vertical position. A GPR survey indicated no anomalies in the immediate or adjacent areas and this suggested that no other human remains were present. Also, an analysis of the GPR data indicated no evidence of a burial shaft associated with the known human remains. d'Aigle and Hryshechko (2002, 2003) concluded that the skeleton was articulated, and based on the presence of human protein in the soil surrounding the skull, that the body had decomposed in place. Analysis of the skeletal remains recovered from the site indicated that they were from a female, approximately 20–30 years of age. No artifacts or other remains were found with the bones and thus no cultural affiliation could be determined. Stable carbon isotope analyses of a tooth fragment suggested that she may have been a resident of the Texas Gulf Coast with marine resources as part of her diet (Tykot, 2002). However, the stable carbon isotope value for the dated petrosal suggested that "this person was not from the Gulf Coast region and was instead from an inland, tropical region significantly distant geographically from the ocean … not from the continental United States" (d'Aigle and Hryshechko, 2002:96). The minimum geologic age of the skeleton, was reported as $10{,}740 \pm 760$ ^{14}C yr BP (AA-45910) (d'Aigle and Hryshechko, 2002, 2003).

The investigations reported here took place in May 2003. At 41BO223, the archaeologically sterile sediments overlying the burial were removed to 50 cm above the highest elevation of the skull. The remaining sediments were hand excavated and all sediments were screened through 1/8 inch mesh. Excavation was difficult because of a high water table and pumps were used to keep water from the excavation area. Once the remains were uncovered, it was determined that they were too fragile to remove as individual elements. Many of the bones were crushed and broken by the weight of the overlying sediments, and by the expansion and contraction of the enclosing clay matrix. To enhance the recovery and preservation of individual skeletal elements, the entire skeleton was pedestaled and wrapped in a hard protective plaster jacket and removed for excavation in the laboratory. At 41BO215, trenches were excavated to examine the stratigraphy and collect radiocarbon samples. At both 41BO223 and 41BO215, the geological stratigraphy was recorded and described. The plaster jacket containing the skeleton was taken to the Physical Anthropology Laboratory at Texas A&M University where it was opened and carefully excavated. Samples of some bones were removed for radiocarbon dating and amino acid compositional analysis. The remaining bones were stabilized with polyvinyl acetate (PVA). Excavated sediments were screened and the bones reconstructed and analyzed. The human remains are now curated at The Center for Archaeological Research, University of Texas, San Antonio.

In 2004, additional studies at 41BO223 and 41BO215 were undertaken (d'Aigle et al., 2005). Based on this additional fieldwork, additional studies, and an independent analysis of the May 2003 excavation data, d'Aigle et al. (2005) reported confirmation of a late Pleistocene age for the skeleton.

The information and interpretations presented in this paper represents only the views of Waters, Wiersema, and Stafford. For additional information and an alternative interpretation of these sites see d'Aigle and Hryshechko (2002, 2003) and d'Aigle, et al. (2005).

3. Physiographic setting of 41BO223 and 41BO215

Both 41BO223 and 41BO215 occur in the lower portion of the western Gulf Coastal Plain about 7.5 km inland from the Gulf of Mexico (Fig. 1). The area is part of the fluvial deltaic system associated with the Brazos River and San Bernard River (Abbott, 2001; Anderson et al., 2004; Aten, 1983). This area is considered part of the subaerial deltaic plain that is frequently covered by floodwaters that overflow small channels draining to the Gulf of Mexico. Previous work determined that both sites lie on the western edge of an abandoned and intermittent fluvial channel, likely related to Cocklebur Slough (d'Aigle and Hryshechko, 2002).

4. Stratigraphy and geochronology of 41BO223 and 41BO215

The stratigraphy and geochronology of 41BO223 and 41BO215 are very similar. Both consist of two fine-grained alluvial units that have been affected by pedogenesis.

The stratigraphy at 41BO223 consists of two fine-grained alluvial units (Fig. 2). Unit 1 consists of silty clay and ranges from 115 to 145 cm below the surface. No primary sedimentary structures are present and the fine-grained sediments have been altered by pedogenesis and bioturbation. The upper 25 cm have been altered into a dark gray, granular, Bt horizon. Below this horizon lies a transitional soil BC horizon of brown silty clay. No A horizon is present, indicating that the top of this unit was truncated after soil formation.

Unit 1 contained the human remains. This skeleton rests entirely within the Bt horizon approximately 1 cm above the BC horizon. The skeleton lies no more than 0.5 m above sea level. In addition, terrestrial, freshwater, and marine shells and lithic artifacts (two pieces of debitage) were found within the Bt horizon of this unit. Non-human animal bones, mostly small mammals and a few large mammals (Cervidae family), were recovered from the Bt horizon. Seven fragments of Cervidae bones, two fragments of unidentified medium-size mammal, and one fragment of unidentified large-size mammal from the

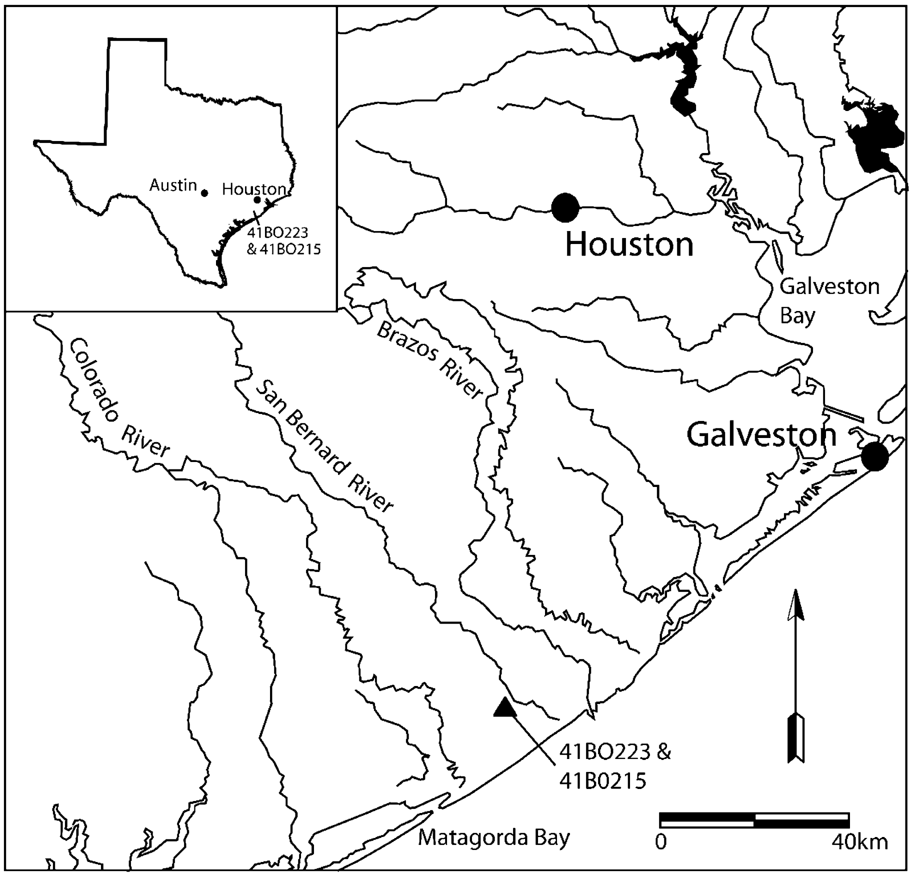

Fig. 1. Map showing the location of sites 41BO223 and 41BO215.

Bt horizon were calcined. Two radiocarbon dates (Table 1) were obtained on the humic acids extracted from this horizon (d'Aigle and Hryshechko, 2002). These humic acids dated to 4870 ± 40 ^{14}C yr BP (CAMS-87686) and 5135 ± 40 ^{14}C yr BP (CAMS-87685). A new radiocarbon date on a single marine *Rangia cuneata* yielded an age of 5590 ± 40 ^{14}C yr BP (CAMS-101892). Two additional ages were obtained directly from the human skeleton (d'Aigle and Hryshechko, 2002): 8700 ± 2300 ^{14}C yr BP (AA-45909) on human teeth and $10{,}740 \pm 760$ ^{14}C yr BP (AA-45910) on bone (a Petrosal). The late Pleistocene ages on the bone contrast with the middle Holocene humate and shell carbonate dates. Samples from the femur, tibia, and humerus obtained during the 2003 investigations were submitted to Stafford Research Laboratories for radiocarbon dating. These samples could not be dated because the bones contained no indigenous protein (collagen).

Unit 2 consists of silty clay and ranges from the surface to a depth of 115 cm. The upper portion of these sediments have been altered by pedogenic processes with a thin A horizon, a dark gray Bt horizon with subangular blocky structure, a transitional BC horizon, followed by unaltered brown silty clay. This unit rests unconformably on Unit 1. No radiocarbon dates were obtained from Unit 2.

The stratigraphy of 41BO215 consists of two fine-grained alluvial units similar to those found at 41BO223 (Fig. 2). Unit 1 consists of a silty clay and ranges from 130 to at least 180 cm below the surface. No sedimentary structures are present and these fine-grained deposits are pedogenically altered. The upper 20–35 cm have been altered into a dark gray Bt horizon with granular structure. Below this lies a transitional BC horizon of silty clay. The top of this unit was truncated after soil formation. This is evidenced by the absence of an A horizon and the variable thickness of the Bt horizon.

A small shell midden, about 3–4 m in diameter, occurs at the very base of the Bt horizon. *Rangia* shells dominate the midden. A few non-human animal bones and sparse lithics were also found. A single *Rangia* from the midden (Table 1) yielded a radiocarbon date of 5585 ± 40 ^{14}C yr BP (CAMS-94573). This is the only radiocarbon date obtained from the site.

Unit 2 overlies Unit 1. Unit 2 consists primarily of silty clay that ranges from the surface to a depth of 130 cm. The upper portion of these sediments have been altered by pedogenic processes and comprise a thin A horizon, followed by several dark gray B and Bt horizons with prismatic structure. This is followed by a transitional BC horizon that is yellowish brown, followed by the C horizon of unaltered sediment. No ages were obtained from this unit.

5. Correlation and depositional history

The proximity of 41BO223 and 41BO215 and their nearly identical stratigraphy, indicate that the two sequences can be correlated with one another (Fig. 2). The sequence of sediments is the same. Both are fine-grained deposits separated by

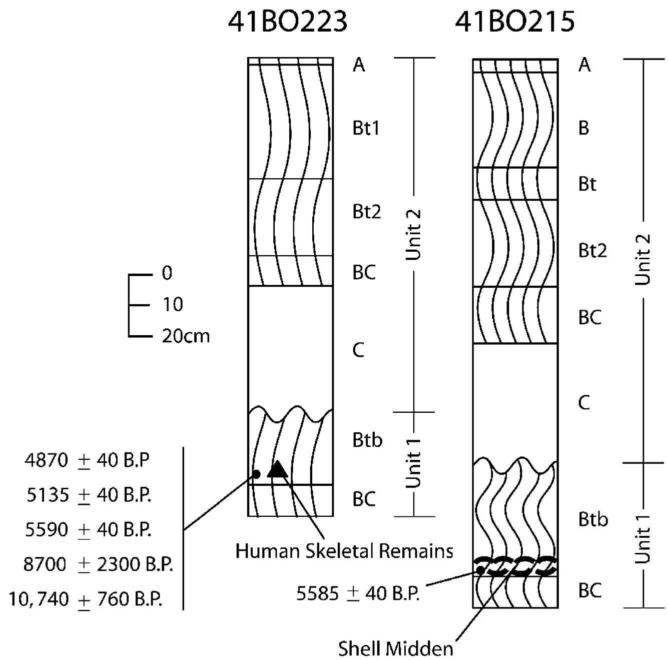

Fig. 2. Stratigraphy of 41BO223 and 41BO215. Showing the position of the skeleton, shell midden, all radiocarbon dates, and proposed correlations.

an unconformity. Furthermore, the degree of pedogenesis and sequence of soil formation at both sites is nearly identical. Finally, the ages from the lower unit (Unit 1) at both localities are similar with the exception of the bone dates. Based on these lines of evidence, it is clear that the sequences at these two sites can be correlated.

The sequence, as represented at both 41BO223 and 41BO215, indicates deposition in a subaerial fluvial environment. Unit 1 was created by overbank flooding when silts and clays were deposited. The floodplain built vertically and pedogenesis followed either during a period of stability or

Table 1
Radiocarbon ages from 41BO223 and 41BO215

Date (^{14}C yr BP)	Laboratory numbers	Remarks
41BO223		
4870 ± 40	CAMS-87686/SR-6210	Humic acids (outside skull) (d'Aigle and Hryshechko, 2002)
5135 ± 40	CAMS-87685/SR-6211	Humic acids (inside skull) (d'Aigle and Hryshechko, 2002)
5590 ± 40	CAMS-101892/SR-6590	*Rangia cuneata*. Shell inorganic carbonate from acid-leached, dense shell
8700 ± 2300	AA-45909	Human teeth (d'Aigle and Hryshechko, 2002)
10,740 ± 760	AA-45910	Human petrosal (d'Aigle and Hryshechko, 2002)
41BO215		
5585 ± 40 yr BP	CAMS-94573/SR-6210	*Rangia cuneata*. Shell inorganic carbonate from acid-leached, dense shell

coincidental with deposition. This was followed by a period of erosion in which the top of the soil was truncated. This was then followed by renewed overbank flooding and the vertical accretion of additional fine-grained sediments. This fluvial activity may be associated with the channel defined by d'Aigle and Hryshechko (2002).

6. The human skeleton

A nearly complete, but fragmented skeleton was recovered over the course of two separate archaeological excavations (Figs. 3 and 4; Table 2). During excavations in 2001, fragments of the skull, mandible, teeth, two cervical vertebrae, and a clavicle were recovered (d'Aigle and Hryshechko, 2002). During the 2003 excavations, the remainder of the skeleton was recovered.

The majority of the elements of the skeleton were in roughly anatomical position. However, the bones of the lower right leg and foot, with the exception of the right talus, were missing (Figs. 3 and 4). The absence of these particular elements is likely the result of post-burial disturbance processes such as prehistoric or historic excavations (e.g., pit excavation) at the site and/or dispersal by crayfish burrowing because fragments of the fibula and tibia were found in the sediments

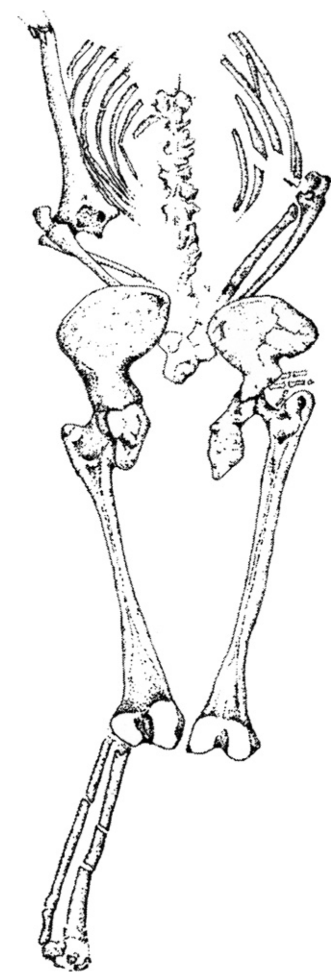

Fig. 3. Posterior view of the skeleton *in situ*.

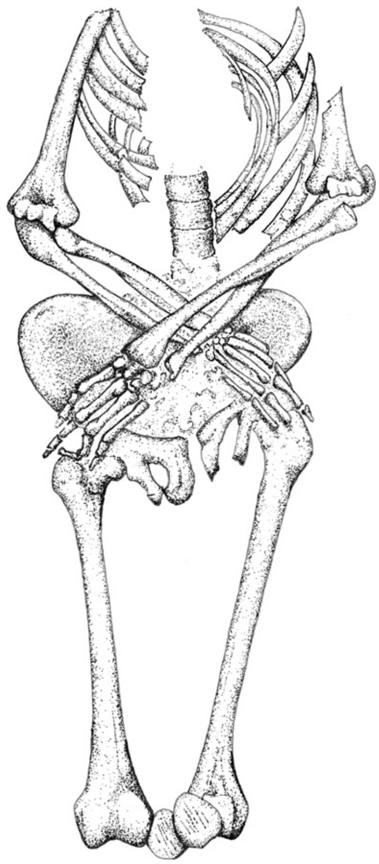

Fig. 4. Ventral view of the skeleton *in situ*.

above the skeleton. The scapulae, sternum, and hand and foot bones were also absent. Their absence is likely the result of postmortem degradation and bioturbation.

The skeletal remains are highly fragmented and physically and chemically degraded. This is the result of postmortem expansion and contraction of the clay in which the remains were embedded, the weight of the overlying sediment, and the fact that the skeleton lay in the zone of a fluctuating water table. Only a few areas of rodent gnawing were noted on the bones and there was no evidence of scavenging by other animals. Root etching was noted on only a few skeletal elements, resulting in only minor damage to the bone surfaces.

7. Mortuary characteristics

Upon initial excavation in 1999, the arrangement of the cranial remains and their particular association with the upper cervical spine, led Steele (2002) to suggest that the 41BO223 remains may have been oriented in an upright burial position, perhaps with legs flexed. Upon excavation of the remainder of the skeleton in May 2003, however, it became evident that the remains were instead oriented roughly north–south (head to south, feet to north) in an extended, horizontal, face-down position, with hands crossed beneath the pelvis (Figs. 3 and 4). These and other characteristics of the burial arrangement indicate a deliberate interment. Additional features indicating a deliberate burial are its horizontal position and the close proximity of the extremities to both one another and each to the trunk. It is possible that the body was wrapped prior to burial to maintain this posture, although no evidence of this was recovered during excavation. The upright position of the cranial remains, as well as their orientation relative to the cervical spine as noted by Steele (2002), may be the result of the body being placed into a burial pit of insufficient length. The head may have twisted as it came into contact with the cranial boundary of the burial pit. Alternatively, the head may have been deliberately placed in that position.

Table 2
Abbreviated inventory of 41BO223 skeletal elements

Anatomical region	Skeletal elements
Cranium	Small isolated fragments of the frontal, parietals, occipital, temporals, maxilla, zygomatics, and mandible
Vertebral column	Fragmentary portion of the cervical spine, and complete but fragmentary thoracic and lumbar spine
Thorax	Portions of most ribs and sternum
Pectoral girdle and upper limb	Fragments of both clavicles, and right scapula. Fragmentary distal 2/3 of both humerii. Both radii and ulnae complete but fragmentary. Numerous elements of both hands (both nearly completely represented)
Pelvic girdle and lower limb	Complete, but very fragmentary left and right innominates and sacrum. Complete but fragmentary left and right femora. Fragmentary left tibia and fibula (right side missing). Most elements of the left foot were represented in fragmentary condition (all but the talus were missing from the right foot)

8. Biological characteristics

The skeleton appears to be that of an adult female. Sex estimation was made largely on the basis of pelvic morphology, with supportive evidence from the remainder of the skeleton. Female indicators include the very wide and shallow left and right greater sciatic notches of the pelvis, a small pre-auricular sulcus on the right innominate, and the degree of rugosity of the auricular surface of the right innominate.

The overall muscularity of the skull, namely of the mastoid and occipital areas, were consistent with female. The profile of the frontal bone of the skull was upright, the extent of gonial eversion present on the fragment of the mandible was minimal, and the supra-orbital margin was fairly narrow and sharp. Measurement of the maximum femoral head diameter yielded a value considerably below the threshold for distinction between males and females (Stewart, 1979). These individual characters are all supported by the relatively small size and nominal muscularity of the remains as a whole.

As indicated by the complete fusion of all of the available epiphyses in the skeleton, the 41BO223 remains are those of an adult. Few elements were available to narrow the age range. The sternal rib ends and the pubic symphysis for example, sustained sufficient postmortem damage to preclude their use in age estimation. The right auricular surface, however, was carefully extracted from the fragmented remains of the pelvis. Employment of the technique devised by Lovejoy et al. (1985) for age estimation from the auricular surface resulted in the classification of the 41BO223 remains into phase two. According to Lovejoy et al. (1985), this stage of degeneration is typical of individuals between the ages of 25 and 29. The lack of degenerative changes to other joint surfaces also supports the notion that the 41BO223 remains are those of a young adult within this age range. The extent of occlusal dental wear apparent on the dentition, though severe, is consistent with other central and southeast Texas Archaic skeletal remains of the same approximate age (Collins, 1998). The degree of wear was greater on the premolars and the 1st molar than on the 2nd molar. This may be the result of more lengthy exposure to abrasive agents due to their earlier eruption. The 3rd molar showed little or no signs of wear in contrast to the remainder of the dentition. A reasonable age estimate of the individual, based collectively on all indicators, is between 20 and 30 years.

The size and stature of the 41BO223 skeleton is, even upon cursory visual inspection, very small. Reliable estimation of the stature of the individual was made difficult by the fragmentary condition of the bones. A stature estimate of 147.3 ± 5.2 cm was estimated using measurements of the nearly complete left femur and Genovese's (1967) stature estimation formula.

The skeletal material generally lacked osteopathologies with the exception of areas of porotic hyperostosis lesions and minimal thickening of portions of the frontal bone of the skull. The appearance of the lesions is indicative of an individual who underwent an episode of iron-deficient anemia as a child, a period of time sufficient to result in the proliferation of marrow cavities within the diploe of cranial bones (Stuart-MacAdam, 1989).

A large number of the teeth showed signs of extensive use-wear. In spite of the extensive wear to each of the teeth, little resorption into the alveolar bone was noted and suggests that the individual likely maintained much of her adult dentition at the time of her death. The wear to the 1st and 2nd left maxillary premolars and the left 1st and 2nd maxillary molars was sufficient to completely penetrate the enamel and expose the underlying dentin. There did appear to be caries in the crown of at least one tooth. Steele (2002) reports that no evidence of hyperplasia was observed on the teeth.

9. Geological age of the skeleton

d'Aigle and Hryshechko (2002, 2003) and d'Aigle et al. (2005) report that the human remains from 41BO223 date to the late Pleistocene. This is based primarily on two radiocarbon ages obtained from the NSF-Arizona AMS Facility at the University of Arizona. Human teeth yielded an age of 8700 ± 2300 ^{14}C yr BP (AA-45909) and a human petrosal yielded a date of $10,740 \pm 760$ ^{14}C yr BP (AA-45910).

As already established in a previous section, the skeleton occurred within the lower portion of the Bt horizon associated with Unit 1. Ages on sediment humic acids derived from the Bt horizon, as well as the shell carbonate fraction of a *Rangia cuneata* shell from this horizon, range from approximately 5000 to 5600 ^{14}C yr BP (Table 1). These dates are similar to the age of ca. 5600 ^{14}C yr BP obtained from the shell midden (41BO215) in a similar stratigraphic context 66 m southwest of the burial. Clearly, the humate and shell ages are significantly younger than the dates derived on bone from the skeleton. The shell and humate dates suggest a middle Holocene age for the skeleton, while the direct bone dates suggest a significantly older, late Pleistocene or early Holocene age. Because different ages have been determined by using different materials for radiocarbon dating, AMS ^{14}C dates on bone versus the radiocarbon ages on sediments and shell, it is necessary to discuss the AMS radiocarbon results in greater detail.

The first consideration is the chemical or protein composition of the bones. As later determined by Stafford, the petrosal dated by the NSF-Arizona AMS Facility had a non-collagenous amino acid composition (Table 3); that is, relative proportions of aspartic and glutamic acids are elevated, hydroxyproline is absent, and glycine is reduced relative to modern bone collagen. A second petrosal sent to Stafford Research Laboratories also had a non-collagenous amino acid composition (Table 3) and accordingly was not dated. A non-collagenous amino acid composition can result from at least three different geochemical pathways: (1) the degradation of collagen whereby

Table 3
Quantitative amino acid analyses comparing 41BO223 *Homo sapiens* petrosal bones to modern bone[a]

Amino acid	Modern bovid bone AAA-1235 (R/1000)	SR-6206 petrosal AAA-1232 (R/1000)	SR-6207A petrosal AAA-1233 (R/1000)	SR-6207B petrosal AAA-1234 (R/1000)
Hydroxyproline*	81	0	0	0
Aspartic acid*	49	238	216	195
Threonine	18	27	27	27
Serine	19	26	33	26
Glutamic acid*	79	146	162	136
Proline*	119	28	30	27
Glycine*	325	203	202	190
Alanine	115	93	90	108
Valine	25	55	50	93
Methionine	5	0	0	0
Isoleucine	13	30	30	30
Leucine	30	49	57	47
Tyrosine	5	7	12	4
Phenylalanine	15	18	22	13
Histidine	7	16	10	24
Hydroxylysine	11	0	0	0
Lysine	30	29	25	0
Arginine	52	34	33	68
Total R/1000	998	999	999	998
nm amino acids/mg of bone	2369	2.0	2.3	1.9
% protein vs modern bone	100	0.08	0.10	0.08

[a] Values are expressed in residues per thousand (R/1000). Protein content is expressed as nanomoles of amino acids per milligram of bone (nm AA/mg bone). Bone with <100 nm AA/mg bone is considered not dateable by current methods. The five amino acids marked with an asterisk (*) are those most important for assessing protein degradation, i.e., is the protein composition collagenous or non-collagenous.

amino acids are differentially leached from the bone, (2) the amino acids are derived from bacterial and other foreign biological materials that have a similar, non-collagenous amino acid composition, or (3) a combination of both collagen-derived and bacteria-derived proteins and amino acid residues are present in the bone. Three additional samples obtained in May 2003 from the femur, tibia, and humerus were also analyzed at Stafford Research Laboratories. Again, the amino acid assays showed a non-collagenous composition of the organic matter (Table 4). The amino acid composition data are an indication that the amino acid spectrum of the bone organic matter is not that of collagen and that dating this type of bone would yield inaccurate ages (Stafford et al., 1991). As a result, it is very unlikely that accurate ages would result from direct dating of the Brazoria skeleton.

Second, the samples that were prepared and eventually dated by the NSF-Arizona AMS Facility were extremely small and the bones' carbon yields were equally low. The teeth yielded 5 μg of ''organic'' carbon, while the petrosal yielded 40 μg of ''organic'' carbon. Minimum sample size for accurate dating is considered to be 100 μg of carbon. More detailed amino acid analyses of both petrosals (Table 3) indicated the presence of 1.9–2.3 nm of amino acids/mg, a value that is 0.1% (1/1000) that of modern bone, which contains ca. 2500 nm of amino acids/mg of bone (Stafford et al., 1991). Bone and teeth that contain less than 100 nm amino acids/mg of sample are not dateable by existing ^{14}C methods. Samples from the tibia, humerus, and femur that were sent to Stafford Research Laboratories yielded similar, very low amino acid contents (Table 4). The tibia, humerus, and femur contained 1–2 nm of amino acids per mg of bone. In this case, the amino acid content is two orders of magnitude below the 100 nm/mg threshold needed for accurate dating.

Table 4
Quantitative amino acid analyses comparing 41BO223 *Homo sapiens* tibia, humerus, and femur bones to modern bone[a]

Amino acid	Modern bovid bone *Bos taurus* femur (R/1000)	SR-6396 tibia *Homo sapiens* AAA-1306 (R/1000)	SR-6397 humerus *Homo sapiens* AAA-1307 (R/1000)	SR-6398 femur *Homo sapiens* AAA-1308 (R/1000)
Hydroxyproline*	93	0	0	0
Aspartic acid*	50	276	264	224
Threonine	19	32	29	22
Serine	33	31	31	25
Glutamic acid*	79	175	167	179
Proline*	115	31	22	25
Glycine*	327	153	176	224
Alanine	113	67	88	90
Valine	20	55	44	22
Methionine	11	0	0	0
Isoleucine	14	31	29	29
Leucine	31	55	55	49
Tyrosine	6	4	11	45
Phenylalanine	14	12	33	9
Histidine	8	8	9	9
Hydroxylysine	8	0	0	0
Lysine	28	31	22	22
Arginine	31	39	22	27
Total R/1000	1000	1000	1002	1001
nm amino acids/mg of bone	2500	1.7	1.4	2.2
% protein vs modern bone	100	0.07	0.06	0.09

[a] Values are expressed in residues per 1000 (R/1000). Protein content is expressed as nanomoles of amino acids per milligram of bone (nm AA/mg bone). Bones with <100 nm AA/mg bone are considered not dateable by current methods. The five amino acids marked with an asterisk (*) are those most important for assessing protein degradation, i.e., is the protein composition collagenous or non-collagenous.

Third, samples yielding less than 0.05 mg (50 μg) of carbon are difficult to date accurately because geological and laboratory contaminations have proportionately greater effect on the measurement's accuracy while measurement precision becomes increasingly large. The two Arizona AMS ^{14}C dates could have been contaminated by carbon with low $^{14}C/^{12}C$ ratios, that is carbon with a fraction of modern ^{14}C values (Fm) that would normally occur in samples over 10,000 ^{14}C years old. The carbon that may have contaminated the Arizona samples could have been derived from at least two sources: (1) from sediments contributing low ^{14}C content organic matter derived from reworked Cretaceous or Tertiary sediments or (2) laboratory contamination from reagents or chemicals used during pretreatment or graphitization. In each case, the contaminant would have small Fm values and have ''apparent'' ^{14}C ages of 10,000 to greater than 55,000 yr BP. The 41BO223 samples yielded 5 μg and 40 μg of carbon. If one-half or more of the final carbon converted into graphite was ancient carbon with a Fm <0.002, the measured age of this combined carbon would be 8000–11,000 ^{14}C yr BP.

Sediment-derived older carbon is an unlikely contaminant for two reasons. First, the organic matter would have to be chemically similar to the fraction dated. Particulate plant organic matter, kerogen or other refractory and geologically ancient (>50,000 yr BP) carbon would have been eliminated during the chemical purification steps. These types of organic compounds would have been excluded chemically from amino acids that were dated. Second, the contaminants most likely to have affected the tooth and petrosal dates are humic or fulvic acids, predominately the latter. However, ancient humates do not appear to be present in the sediments enclosing the bones because sedimentary humic acids yielded ages of ca. 4900–5100 ^{14}C yr BP (d'Aigle and Hryshechko, 2002) (Table 1). Consequently, it is unlikely that sediment-derived, ancient carbon contaminated the teeth and petrosal samples.

Inherent problems in measuring the concentrations of carbon isotopes in very small samples also resulted in the large standard deviations associated with the two ages generated by the NSF-Arizona AMS Facility. One has a one-sigma error of 2300 years and the other 760 years. In fact, the tooth sample has such a wide standard deviation that it could either date to the late Pleistocene or to the middle Holocene, close to the ages generated by the shell and humate samples.

The geologic context and invertebrate remains found at the site also provide additional evidence relevant to determining the age of the human remains from 41BO223. The human remains at the site were found within the lower portion of the Bt horizon associated with Unit 1. These deposits can be correlated with those at 41BO215 where a shell midden was found in the same stratigraphic position. A radiocarbon measurement on *Rangia cuneata* shell carbonate from this site yielded a date of ca. 5600 ^{14}C yr BP. This agrees well with the shell date from 41BO223. Additionally, the late Pleistocene age for the skeleton is discordant with the presence of a brackish water *Rangia cuneata* within the Bt horizon of Unit 1 at both 41BO223 and 41BO215. During the late Pleistocene, sea level would have been lower than today (ca. −35 m at 11,000 ^{14}C yr BP) and at least 30 km seaward of 41BO223 and 41BO215. It seems unlikely that a shell midden would have been created this far inland from its source during the late Pleistocene. It seems more reasonable that the shell midden was created during the middle Holocene when sea level was much closer to its present position and not a great distance from 41BO223 and 41BO215.

In summary, the 41BO223 Brazoria site's human bones have a non-collagenous amino acid composition, and less than 1/1000th their original organic matter content. It is unknown if this small amount of amino acids was derived from the bones' original collagen, but it is unlikely. Bone samples analyzed by the NSF-Arizona AMS Facility and others sent to Stafford Research Laboratories all had similar, very low organic matter contents and non-collagenous compositions. The collagen would have been destroyed by fluctuating, oxidizing water tables, as indicated by the bones' high ferric iron and manganese contents.

The non-collagenous amino acid composition, the low organic matter content, and the microgram yields all preclude the bones from yielding accurate radiocarbon or stable isotope measurements. Finally, it is possible that the measured ages on two 41BO223 human bones are too old because ancient carbon was incorporated into the sample during laboratory processing.

In conclusion, we consider the ca. 10,740 ^{14}C yr BP date for the human bones to be erroneously too old. Instead, an age of ca. 5600 ^{14}C yr BP is postulated for the skeleton and this conclusion is based on geology, ^{14}C dates on shell from 41BO223 and humic acids enclosing the skeleton, and consideration of the regional paleoecology for the brackish water mollusk *Rangia*.

10. Stable carbon isotope analyses

Two stable carbon isotope values derived from the skeleton were reported by d'Aigle and Hryshechko (2002, 2003). These were used to interpret the diet of the individual and provide data on the origin of this person. One sample of tooth enamel was analyzed by Tykot (2002). He obtained a value on the enamel of $-10.5‰$. Tykot (2002:167) concluded that C_4 plants contributed "25% of the diet at the time of crown formation." He also concluded that "marine foods from the Gulf contributed significantly to this individual's diet." Tykot (2002:167) concludes that "the isotope result obtained on this single tooth is consistent with residency along the Gulf Coast." It is interesting to note that the radiocarbon age obtained from the tooth, given the standard deviation, could date to the middle Holocene.

A stable carbon isotope value of $-26.5‰$ was obtained by the NSF-Arizona AMS Facility on the petrosal organic carbon dated as $10,740 \pm 760$ ^{14}C yr BP (AA-45910). Tykot (2002) noted that this value was not consistent with the isotope value obtained from the tooth. Tykot (2002:167) comments, "… if done on a sample of intact collagen … [the stable carbon isotope value] … is not consistent with any marine food or C_4 resource consumption, and suggests residence in an environment in which there was no free circulation of atmospheric carbon dioxide such as under the canopy of a tropical forest." d'Aigle and Hryshechko (2002:171) based on the petrosal's isotope value, concluded that "this person was not from the Gulf Coast region and was instead from an inland, tropical region significantly distant geographically from the ocean." d'Aigle and Hryshechko (2002:96) believe the tooth enamel specimen was less reliable for such analyses because they felt for various reasons that the tooth was likely more "degraded than it appears."

The amino acid analyses showing that the petrosals and other human bone from 41BO223 had a non-collagenous amino acid spectrum, cast doubt on the validity of the stable carbon isotope measurements on the petrosals. Interestingly, it may be the tooth that yielded the most accurate measurement, both in ^{14}C and stable isotopes. Tykot (2002) concluded that marine foods were an important part of the individuals diet. This finding is consistent with the presence of *Rangia* at 41BO223, the close proximity of the shell midden at 41BO215 in correlative deposits, and with the proposed middle Holocene age for the skeleton.

11. Summary

The nearly complete, but fragmentary human skeleton of a young adult female was recovered from 41BO223 in Brazoria County, Texas. This person, was intentionally buried. The skeleton was lying in a face-down extended position with hands crossed beneath the waist. No preserved grave goods were found with the burial. Analysis of the previous radiocarbon dates obtained from the skeleton as well as new radiocarbon dates and amino acid composition results suggest that the skeleton likley dates to about 5600 yr B.P. Two characteristics ally the burial from Brazoria County with the middle Archaic burial sites in southeastern Texas (Hall, 1981, 1995; Taylor, 1995). The first is the dearth of burial goods associated with the remains and the second is the extended position of the remains. The burial appears to be unusual in its mortuary characteristics relative to its Archaic contemporaries in that the skeleton was buried face down with hands neatly crossed beneath the pelvic area.

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