PRELIMINARY GEOARCHAEOLOGICAL STUDIES AT COLUMBIA PARK, KENNEWICK, WASHINGTON, USA.

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INTRODUCTION

In August 1996 a well preserved, disarticulated human skeleton was found submerged in Lake Wallula within 7 m offshore at Columbia Park in Kennewick, Washington. Radiocarbon analysis of bone protein from the fifth metacarpal of the left hand by Dr. Irving Taylor, University of California, Riverside yielded $\delta^{13}C$-corrected age of 8410±60 years B.P. (UCR-3476). The calendar-corrected age of this measurement is approximately 9300 years B.P. (7265-7535 B.C.). The skeleton's anatomy (non-Mongoloid physical features) and great antiquity attest to its tremendous scientific importance to New World archaeology. The skeleton's scientific value dictated that its geologic age and context be known to the highest degree of certainty.

On August 26, 1997 an ARPA permit application was submitted by Drs. Gary Huckleberry (Washington State University), Robson Bonnichsen (Oregon State University), C. Vance Haynes, Jr. (University of Arizona), James Chatters (Applied Paleoscience, Washington), and Thomas Stafford, Jr. (Stafford Research Laboratories, Inc., Colorado) to the U.S. Army Corps of Engineers (USACE), Walla Walla District. The application requested permission to perform limited geoarchaeological testing at the skeleton's discovery site (herein referred to as "Site"). Specific objectives of the investigation were:

- Identify and record geomorphic features in the project area;
- Identify, sample and map stratigraphic and soil units at the Site;
- Collect samples of paleobotanical and faunal specimens that may be exposed in bank deposits;
- Determine if any intact archaeological deposits are present at the Site;
- Collect samples of organic materials for radiocarbon dating.

The goals of the investigation were to determine:

- If the geologic age of the Site is consistent with the radiocarbon age of the skeleton;
- Whether or not the skeleton was deposited at the Site by natural or human processes;
- If the Site has been disturbed by geological, biological or cultural activities that occurred after the initial deposition of the skeleton;
- What factors may have contributed to preservation of the skeleton over time;
- If there was human occupation at the Site during, prior to, or following deposition of the skeleton;
- If the Site is subject to any unusual conditions that might affect the reliability of radiocarbon dates taken from the skeleton or other organic materials.

USACE stated on October 31, 1997 that the permit request would be granted, but to date it has not accepted the research design. In November 1997, USACE decided that noninvasive, limited testing would be performed at the Site, that the investigation would be led by geologists from the USACE Waterways Experiment Station (WES), Vicksburg, Mississippi, and that field investigations would be limited to the streambank. This investigation included members of WES, the Huckleberry team (Drs. Huckleberry, Chatters and Stafford) and representatives of the Confederated Tribes of the Umatilla Indian Reservation, the latter having submitted a competing application to perform

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geoarchaeological testing. Fieldwork was performed December 13-17, 1997 and the results of the investigation conducted by the Huckleberry team are presented in this report.

GEOMORPHIC CONTEXT

The project area is located in the Pasco Basin, a subdivision of the Columbia River Basin (Figure 1). Due to the rainshadow effect of the Cascade Mountains, the Pasco Basin is one of the driest regions in Washington state. Mean annual precipitation in Kennewick is 19 cm (Rasmussen, 1971) most of which falls in winter. The prevailing wind pattern is from the southwest and is expressed in the orientation of eolean landforms in the region, many of which date back to the Pleistocene. Natural vegetation on well drained, upland surfaces is dominated by sagebrush (*Artemesia tridentata*) and grasses such as *Agropyron spicatum* (Daubenmire, 1970). Riparian plants along watercourses include cottonwood (*Populus* sp) and willow (*Salix* sp). Much of the natural vegetation has been modified by over 100 years of agriculture and introduction of exotic species.

Topography is relatively flat in the Pasco Basin due to the mostly horizontal layers of Miocene flood basalts that extend more than 3,000 m in depth (Easterbrook and Rahm, 1970:110; Hooper, 1982). To the west are a series of anticlinal folds that create dominantly east-west trending ridges; two of these anticlines aligned northwest-southeast form the Rattlesnake and Horse Heaven Hills southwest of Kennewick. The Miocene basalts are mantled with a variety of Pliocene and Quaternary age lacustrine, alluvial, and eolian deposits. Late Pleistocene age sediments are directly or indirectly related to the several outburst floods associated with glacial Lake Missoula (Baker et al., 1991; Baker and Nummedal, 1978). Periodic collapses of ice dams on a segment of the Clarks Fork River in northern Idaho instantaneously released large volumes of water. These cataclysmic floods scoured much of eastern Washington and deposited considerable alluvial and lacustrine sediment in the Pasco Basin where waters would back up at the Wallula Gap constriction (O'Connor and Baker, 1992). A high terrace situated above Columbia Park underlies the town of Kennewick and is composed of fluvial gravels associated with the outburst floods (Reidel and Fecht, 1994). The frequency and timing of the outburst floods are still debated. However, the last flood appears to have occurred no later than approximately 13 ka[1] because post-flood deposits contain Glacier Peak volcanic ashes B and G which date circa 11.3 ka (Baker et al., 1991:244)). Many of the sediments deposited in the Pasco Basin during the Missoula Floods have been subsequently reworked by wind and water during the Holocene, resulting in smaller-scale landform features such as alluvial fans and terraces as well as eolian sand sheets and dunes.

The Kennewick Man discovery site is situated on a low terrace on the south side of the Columbia River at river mile 331.6, at an elevation of 104 m above sea level. The mouth of the Yakima River is approximately 5 km upstream from the Site. At the Site's location, there is a discontinuous series of narrow alluvial terraces that closely parallel the edge of the Columbia River and are inset below higher elevation Pleistocene terraces formed by the Missoula floods. No systematic study of these lower terraces has been performed along the middle reach of the Columbia River. Based on topographic position, these low elevation terraces correlate with post-glacial terraces found along the Columbia River upstream from the Hanford Nuclear Reservation (Chatters and Hoover, 1992). Such terraces are characterized by basal gravels conformably overlain by sandy, horizontally bedded, vertical accretion deposits that are capped by a sandy eolian mantle. It is uncertain what is the effect of relict landscape features produced by the Missoula floods on the spatial

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[1] 1 ky = 1,000 years; 1 ka = 1 ky ago (North American Commission on Stratigraphic Nomenclature, 1983).

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Figure 1. Regional shaded relief map of study area (adapted from U.S.G.S. 1:250,000 Walla Walla 1X2 degree DEM).

patterning of post-glacial stream terraces along the Columbia River. It is possible that terrace, bar, and ripple sequences associated with the outburst floods affects the location of Holocene alluviation.

During the early Holocene, the Columbia River downcut and formed the terrace at Columbia Park. Subsequent to downcutting, the main sources of sediment to the terrace would be alluvium derived from tributaries originating on higher Pleistocene terrace surfaces and eolian sands locally derived from elsewhere on the terrace or from upland surfaces to the south and west. At the site, the terrace would have been relatively well drained during the Holocene. This changed, however, after Anglo-European settlement when irrigation canals were constructed for agriculture. In 1892, the first canals constructed on the Yakima River (Rasmussen, 1971:66) diverted water onto the terraces in the Kennewick area resulting in locally elevated water tables. Historic aerial photography from 1930 indicates that the terrace at Columbia River Park was previously under cultivation. Periodic saturation of the low elevation terraces would have been further enhanced by the construction of McNary Dam and creation of Lake Wallula. Today the site supports a wetland plant community.

METHODS

WES designated a 345 m section of streambank at Columbia Park as the study area (Figure 2) which extends 45 m downstream and 300 m upstream from the skeleton locality. This corresponds to where the terrace contains 1-2 m thick exposures of fine-textured sediment in the streambank. Site preparation (cutting vegetation, establishing survey monuments and designating stratigraphic column position) was performed largely by USACE personnel (Table 1). A line of survey monuments was established by survey crews of the Walla Walla District on the terrace tread and referenced to UTM coordinates. WES demarcated 12 stratigraphic columns along the streambank at intervals ranging from approximately 10 m apart at the skeleton locality to 30 to 40 m apart at locations upstream and downstream (Figure 3). Each stratigraphic column was approximately 0.5 to 1.0 m wide and 1.5 to 2.0 m in depth. Sediment removed during facing was screened through 1/4-inch mesh by WES and Umatilla personnel.

Stratigraphic descriptions of the control columns were made independently by WES personnel and Drs. Huckleberry, Chatters, and Stafford (Appendix A). Soil pedon descriptions (Appendix C) were made by Huckleberry following guidelines of the U.S. Soil Survey Manual (Guthrie and Witty, 1981; Soil Survey Staff, 1954) combined with nomenclature used in Quaternary pedology (e.g., Birkeland et al., 1991). In addition, Stafford and Chatters described a stratigraphic profile along a discontinuous bank exposure between CPP044 and CPP097 (Figure 5). The profile was created by cleaning with trowels a continuous section from CPP094 to CPP080 and cleaning 50 cm wide sections every 2 to 3 m from CPP080 to CPP044. Stratigraphic contacts were delineated to ± 3 to 5 mm precision, lithologies and bedding forms were described throughout, with the goal of correlating tephra-bearing sediments to those yielding the skeleton.

Sediment samples were collected by WES and the Huckleberry team. Detailed sediment sampling at systematic intervals was performed at CPP044, CPP054, CPP094, and CPP334 by Stafford, Chatters, and Huckleberry. Continuous samples were taken in 5 cm thick intervals or 5 cm immediately above and below stratigraphic boundaries; samples for radiocarbon dating of soil organic matter were taken in 2 cm thick intervals, and 2 cm immediately above and below horizon boundaries. Intermittent sediment sampling by soil horizon was performed at CPP093 and CPP233 and areas adjacent to CPP200 and CPP296 by Huckleberry for general stratigraphic and pedologic characterization. A total of

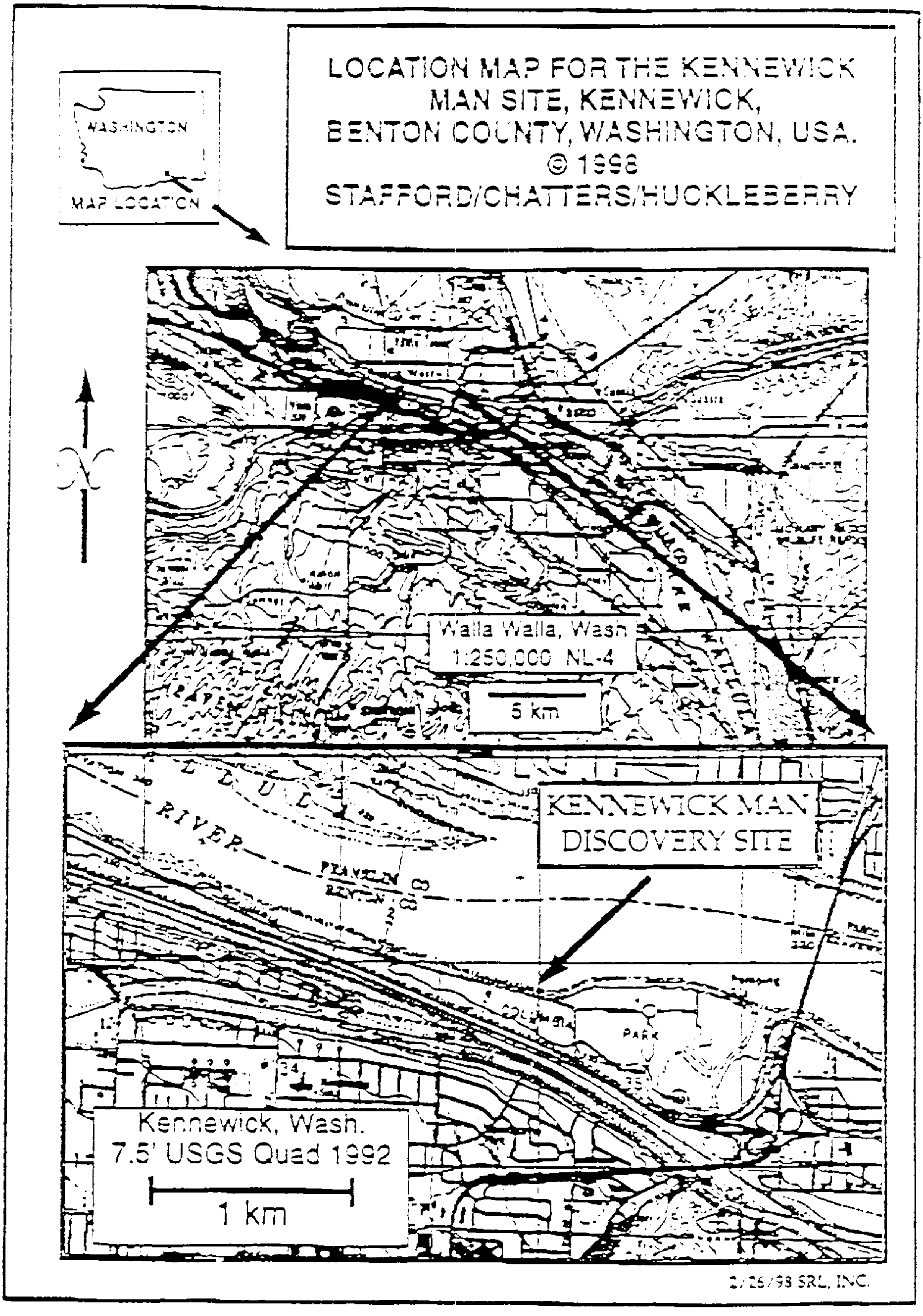

Figure 2. Location map of the project area.

Table 1. Field Tasks Performed by Investigative Teams at the Kennewick Man Site, December 13-18, 1998

USACE WES	USACE, Walla Walla District	Huckleberry et al.	Confederated Tribes of the Umatilla Indian Reservation
• established stratigraphic column locations	• established survey control	• profiled stratigraphic columns[1]	• screened sediment removed during profiling
• screened sediment removed during profiling	• contracted ground penetrating radar study along shore by CH_2MHill	• soil pedon descriptions[2]	• recorded any cultural features and artifacts
• profiled stratigraphic columns		• topographic map surveyed with EDM at skeleton locality	• contracted site inspection by geologists from Pacific Laboratory (Richland)
• soil pedon descriptions		• constructed discontinuous profile at skeleton locality[3]	
• vibracore sampling along shore		• collected sediment samples from stratigraphic columns	
• collected sediment samples from stratigraphic columns			
• contracted pedologist from USDA Lincoln Laboratory for pedologic analysis			

[1] Assisted by the following graduate students from the Department of Anthropology, Washington State University (Pullman): Diane Curewitz, Jonathan Dana, Dianna Georgina, Amy Holmes, David Johnson, Katherine Kramer, and Michelle Ross.
[2] Soil pedon descriptions performed by Huckleberry and Dr. Donald Wysocki of Oregon State University Agricultural Extension Office, Pendleton.
[3] Assisted by Emily Lindsay.

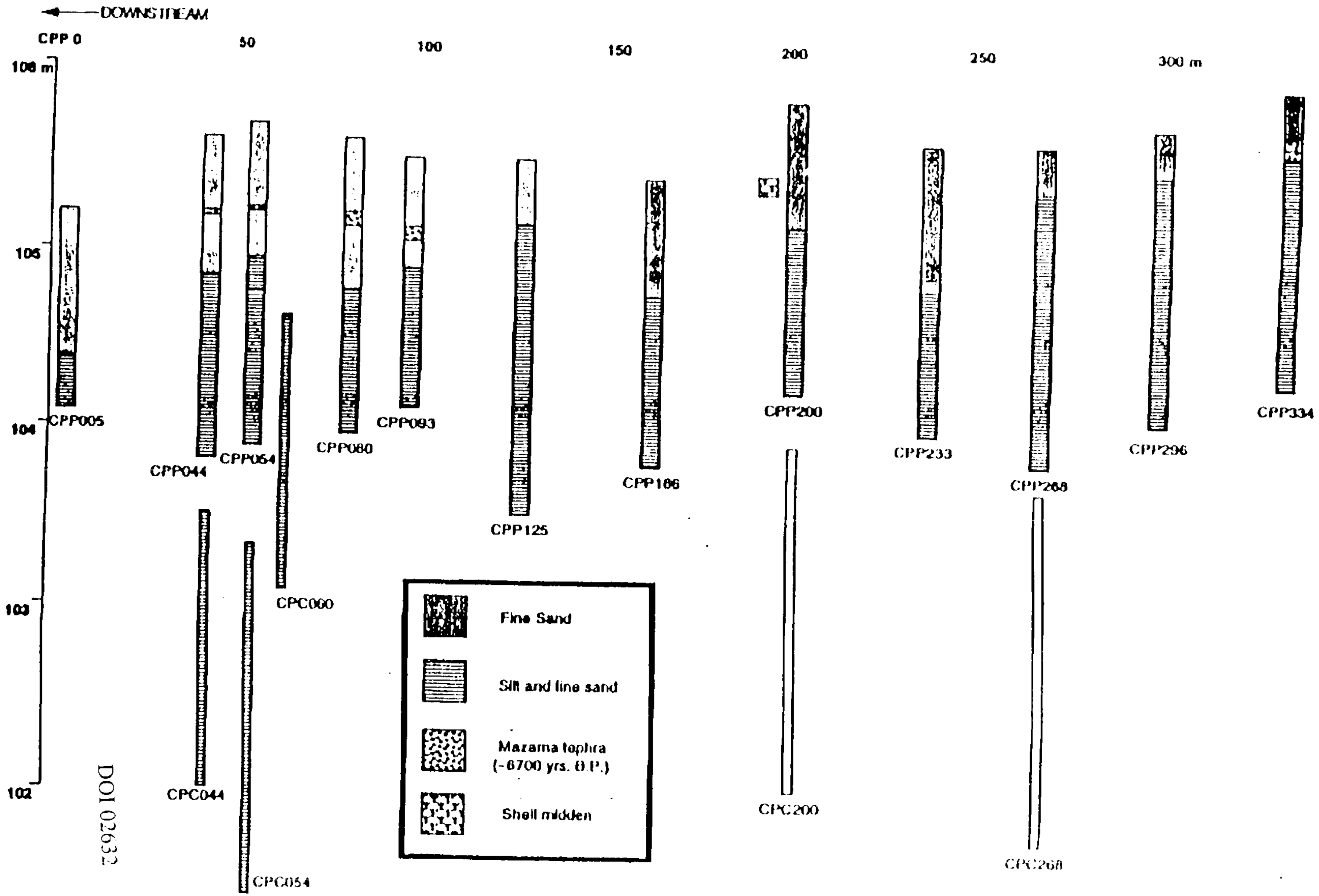

Figure 3. Location and general stratigraphy of control columns and subsurface cores.

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157 sediment samples were collected by Huckleberry, Stafford, and Chatters. All samples to be used for radiocarbon dating were stored in new plastic bags and were refrigerated at 4° C immediately after collection. In addition to streambank sampling, a series of approximately 2 m-long Vibracores was taken by WES personnel along the shore; a duplicate set of cores was taken from CPP044, CPP054, CPP060, CPP200, and CPP263 and given to Huckleberry for analysis. Huckleberry arranged for a total station topographic survey of the area between CPP044 and CPP093 by Robert Wegener and Dr. Robert Ackerman of Washington State University Department of Anthropology.

Granulometric analysis was performed on selected sediments from CPP093 in the Geoarchaeology Laboratory at Washington State University. Samples were dry sieved and the fine (< 0.5 mm) fraction was analyzed in a settling tube with a hydrometer (Bouyocous, 1962). Thin-section analysis was performed at the WSU Geoanalytical Laboratory by Sandra Lillegren on sediment samples collected at CPP044, CPP093, and CPP296. An electric pH meter was used on sediments mixed at different ratios with a 0.01 molar calcium chloride solution (McClean, 1982). Most of the sediments have yet to be analyzed pending establishment of the final sample data set (See CONCLUSIONS AND RECOMMENDATIONS below).

GENERAL STRATIGRAPHY

Two lithostratigraphic divisions, Units I and II are consistently exposed along the 345 m long exposure of stream bank within the project area. At the surface is Unit I which is composed of loose to friable fine sand to very fine sand and ranges from 25 to 80 cm in thickness (Figure 3; Appendix A). The upper 10-35 cm of Unit I have been mixed, presumably by agricultural processes. The middle and lower parts of Unit I are massive and also lack internal bedforms which appear to have been disturbed by bioturbation. No vertical or horizontal grading is observable. Unit I is slightly calcareous and contains a dark brown organic horizon at the surface. In places, a white tephra layer is discontinuously preserved at or near the base of Unit 1 (Figure 3). The tephra is best expressed upstream, at the far western edge of the project area at CPP334, where the tephra attains a thickness of 15 cm, appears relatively pure (Appendix A: CPP334), and can be continuously traced laterally approximately 25 m downstream. At the skeleton locality, between approximately CPP057 to CPP093 the tephra occurs as small (< 5 mm), irregular concentrations and has clearly been mixed into the sediment matrix (Appendix A: CPP054, CPP080). A tephra sample was collected from CPP334 and chemically identified (Sarna-Wojcicki, 1998) as originating from the eruption of Mount Mazama. The Mount Mazama eruption occurred where Crater Lake National Park, Oregon is today and has been independently dated at approximately 6700 ^{14}C yrs. B.P. (Sarna-Wojcicki, 1998; Sarna-Wojcicki and Davis, 1983). Additional temporal control for Unit I comes from two ^{14}C ages from freshwater shell carbonate. One sample (Beta-113838) from CPP005 (60-80 cm depth) yielded a conventional ^{14}C age of 6230±60 yrs. B.P. (one σ standard deviation) or a calendar calibrated age of BC 5520 to 5305. The other sample (Beta-113977) from a shell midden located at 45 cm below the surface near CPP200 yielded a conventional ^{14}C age of 6090±80 or a calendar calibrated age of BC 5070 to 4915. Although the tephra and shell ages are apparently contemporaneous, radiocarbon dates on fresh water shell carbonate can be either too old due to old-carbon reservoir effects, or too young due to modern carbon contamination by groundwater exchange. Because of reservoir carbon conditions, shell carbonate dates can be too old by as much as 2000 years compared to radiocarbon ages on associated charcoal (Chatters, 1986).

Information derived for the lower lithostratigraphic interval, Unit II, is taken from the streambank which exposes the upper 1.0-1.5 m of the deposit, and sediment cores which penetrated the deposit an additional 2.0 m below the lake level. Unit II is finer grained, has more stratification and bedding preserved, is less oxidized, and has more pedogenic horizons than Unit I. Unit II consists of horizontal, weakly bedded fine sand, very fine sand, and silt (Figure 3; Appendix A). The contact of Units I and II extends 1 to 4 cm and is based on increased sand content and oxidation in Unit I, and more massive structure of Unit I sands. The boundaries between beds within Unit II are gradual in the upper 2 m and they appear to have been bioturbated. Below 2 m, the contacts between fine sand and silt and very fine sands are abrupt and reveal several coarse-to-fine graded vertical sequences (Appendix B: CPC054). At CPP044, upward fining stratification was visually absent; however, centimeter-scale field lithology analysis revealed faint fining upward stratification in at least six beds. At CPP080±2 meters, there was faint stratification resembling climbing ripples within Unit II. Bed thickness ranges from 5 cm in the lower part of Unit II to 50 cm in the upper part. In places, the sediments are mottled gray and orange indicating alternating oxidation and reduction of iron, a byproduct of periodic saturation and aeration or fluctuating water tables (Rowell, 1981). At the discovery site, the Unit II sediments are predominantly reduced and have gleyed colors (2.5Y). In the upper part of Unit II, two silty layers contain abundant, irregularly shaped calcitic concretions which appear to be root or insect burrow casts (See POST-DEPOSITIONAL PROCESSES below). These concretions are scattered along the shore as a coarse lag deposit, and are also abundant in beach sands that unconformably cap the top of the sediment cores taken along the shore (Appendix B).

The locality of the skeleton discovery is along the shore between CPP057 and CPP093 (Figure 4). Here both lithostratigraphic units are exposed discontinuously (Figure 5). Unit I ranges from 60 to 75 cm thick and has a gently undulating base. It contains little internal stratigraphy except for a zone 10-20 cm thick of disturbed Mazama tephra that can be traced from CPP093 to CPP054. Unit II can be subdivided into layers of fine sandy alluvium with varying silt and clay content. In the upper 1.0 m of Unit II, there are two relatively fine-textured layers, one at approximately 75-100 cm below the modern surface, and the other at approximately 125-150 cm below the modern surface. Both of these layers contain calcitic concretions and are separated by a very fine sandy layer with less silt and clay. These layers have been mixed, and their contacts are gradual.

Only one other deposit in addition to the upper and lower lithostratigraphic units was identified in the streambank. Just upstream from CPP344 is a shallow (< 1 m) exposure of well rounded fluvial gravels of diverse felsic and mafic lithologies. These gravels continue upstream for 20 m. The surface of the exposure slopes upward to the south and may be part of an alluvial fan formed by a tributary draining an upper Pleistocene stream terrace. The alluvial gravels may have two sources: 1) they are reworked from the older, gravely terrace, or 2) they were anthropogenically emplaced to stabilize the bank. Although the stratigraphic relationship between the gravels and the two main lithostratigraphic units was obscured by dense root mats, the shallow depth of the gravels suggests that if the gravels are natural, then they are coeval with the upper lithostratigraphic unit. The well preserved nature of the Mazama tephra at this end of the project area may be due to the alluvial fan. Mazama tephra beds in the Columbia Basin tend to be best preserved in alluvial deposits associated with low order tributaries (Baker et al., 1991).

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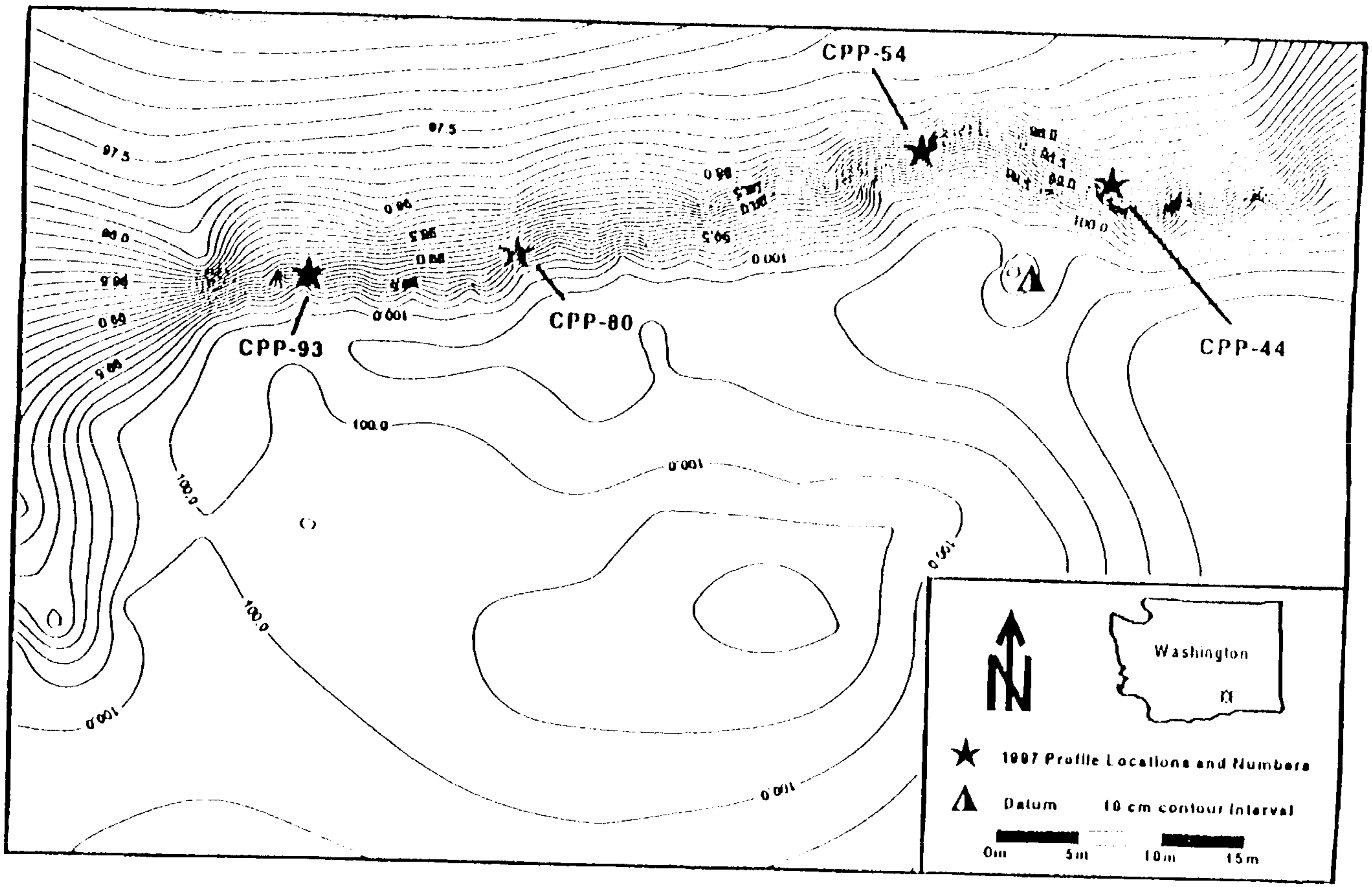
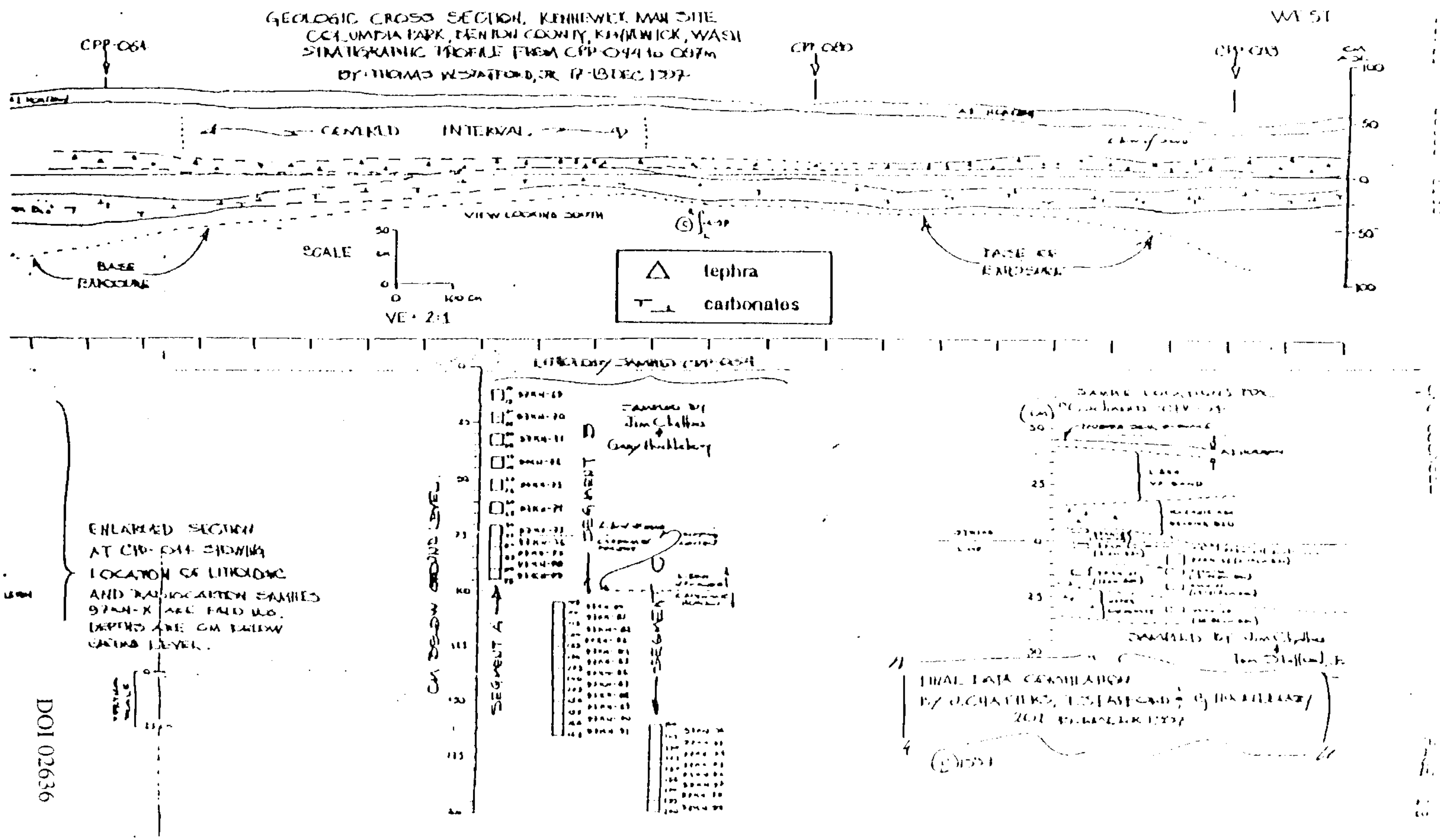
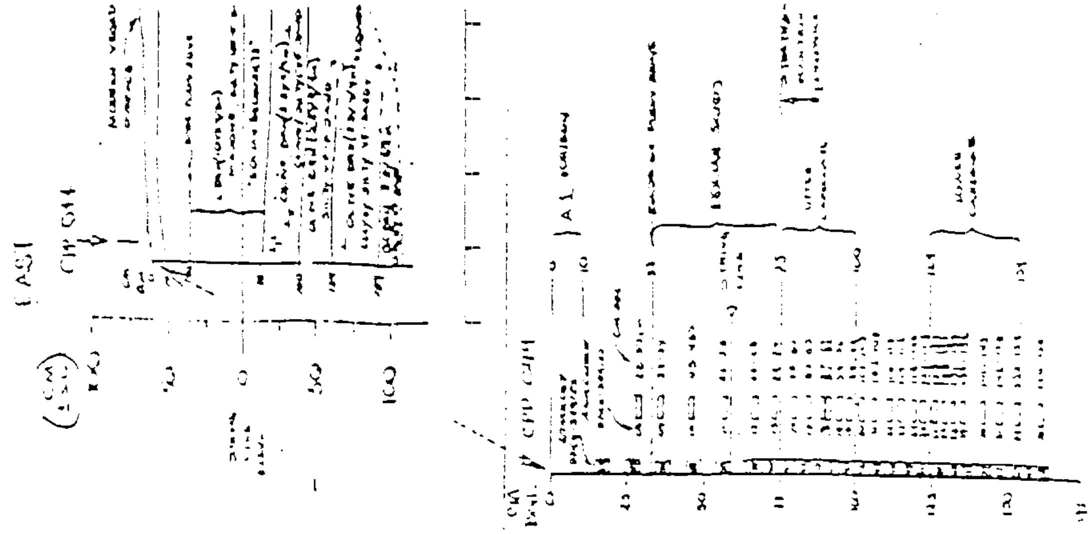


Figure 4. Topographic map of skeleton locality.

Figure 5. Geologic cross-section, CPP044 to CPP093.





POST-DEPOSITIONAL PROCESSES

Sediments exposed along the streambank at Columbia Park have experienced post-depositional processes including soil formation and erosion. The main evidence for soil formation includes

- Bioturbation and destruction of primary bedding;
- A horizon development at the terrace surface;
- Cambic B horizon development marked by precipitation of secondary calcium carbonate and silica.

This soil development is common to Holocene surfaces located in the drier parts of central Washington where precipitation is < 450 mm (Busacca, 1989). At Columbia Park, A and Bk horizons are developed into Unit I; Bk and Bkq horizons are developed into Unit II

Unit I

The A and Bk horizons have a sandy loam texture and pH values close to 8.0 (Table 2). The A horizon has a moist color of 10YR3/3 and a thickness of 5-10 cm. It is well mixed and contains abundant earthworm fecal pellets. Although it meets the color requirement, this horizon is too thin to classify as a mollic epipedon, despite the soil being mapped by the U.S. Soil Conservation Service as the Pasco silt loam, a Cumulic Haploxeroll (Rasmussen, 1971; Soil Survey Staff, 1994:226). Without more laboratory data, it is uncertain how this soil classifies. The B horizon in Unit I is classified as cambic and defined mainly by slight calcification with no visible carbonates. The color is predominantly olive brown (2.5 Y 4/4, moist) with no obvious signs of reddening.

Unit II

In Unit II, B horizon textures include silt loam, loam, and sandy loam (Table 2). Soil pH is lower than in Unit I and may reflect different redox conditions due to greater moisture retention. Calcification is more advanced and expressed in finer textured layers as irregular concretions (Stage II carbonate development). Carbonates are generally not visible in the sandier layers of Unit II. Concretion shapes include amorphous equant aggregates, tubules, and dendrites ranging 5-10 mm in thickness. Reaction to hydrochloric acid ranges from slightly to strongly effervescent. The tubules and dendrites are likely the casts of roots and possibly worm, cicada, and other invertebrate burrows. Despite pedogenic modification of Unit II, subtle horizontal bedding is still recognizable.

In addition to calcification, soils at the Site display evidence of secondary silica accumulation. Near CPP296, a cemented layer approximately 10 cm thick occurs at the top of Unit II (Soil Profile KM1 in Appendix C). Fragments of this layer do not slake in water and have a relatively mild reaction to hydrochloric acid. It is probable that this layer represents a duripan (Soil Survey Staff, 1994:9), a subsurface horizon formed by the concentration of secondary silica. Secondary silica commonly forms in alkaline, well drained Holocene soils that contain tephra or silica-rich clasts (Chadwick et al., 1988; Cooke et al., 1993:62). Soils in the study area have a readily available supply of silica derived from dissolution of highly weatherable volcanic ash. Under existing pH conditions, silica in the tephra dissolves and percolates downward. Under humid conditions, the silica is leached from the solum, but in arid and semiarid environments, the secondary silica may precipitate in the B horizon. Secondary silica development in soils proceeds in a series of morphological stages. In gravely soils, the silica first precipitates in

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Table 2. Laboratory Data for Soil Profile KM3, Columbia River Park (See Appendix C for Pedon Description).

Dry Sieve Particle-size Data (Individual weight %)

Horizon	-1.0 Φ	0 Φ	0.5 Φ	1.0 Φ	1.5 Φ	2.0 Φ	> 2.0 Φ
A[1]	0.1	1.0	1.5	2.9	6.5	6.3	81.7
Bk1	0	.01	.05	.13	.30	.51	98.85
Bk2	0	0	0	.02	.06	.09	98.40
2Bk3	.46	.53	.41	.52	.88	1.19	95.38
2Bk4	.07	.11	0	0	1.7	2.12	94.5

Hydrometer Particle-size Data

Horizon	% Gravel	% Sand	% Silt	% Clay	USDA Textural Class
A[1]	0	62	29	9	sandy loam
Bk1	0	52	43	5	sandy loam
Bk2	0	42	45	13	loam
2Bk3	0	40	50	10	silt loam to loam
2Bk4	0	59	31	10	sandy loam

pH (.01 M $CaCl_2$ solution)

	Soil:Water Ratio		
Horizon	1:1	1:2	1:10
A	8.3	8.3	7.8
Bk1	8.5	8.0	7.9
Bk2	8.0	7.6	7.7
2Bk3	7.7	7.6	7.4
2Bk4	7.6	7.5	7.3

[1] A horizon particle-size data is from Soil Profile KM2.

the form of pendants and coatings on clasts and may eventually cement the entire matrix forming a silcrete (Harden et al., 1991). In fine textured soils, silica first concentrates at foci forming durinodes and if allowed to proceed will eventually cement the entire matrix into a silcrete. At a macroscopic scale, zones of secondary silica and calcite accumulation are often indistinguishable. However, they are distinguishable at a microscopic scale where silica and calcite accumulate separately in the soil matrix (Chadwick et al., 1987). Thin-section analysis of a duripan (in place) at Soil Profile KM1 (Appendix C) and a calcareous concretion collected in a lag deposit at the base of the profile confirm the presence of both constituents. Amorphous silica is visible along the linings of interstitial pores separate from the predominant calcitic matrix. It is unknown how much silica is incorporated into calcitic concretions in Unit II elsewhere at the Site.

Duripans at the Site are best developed at the contact of Units I and II at the western end of the project area near CPP344. Duripan development at this stratigraphic position is probably related to the contrasting textures above and below the contact. Waters percolate relatively easily throughout Unit I but concentrate in the relatively fine textured upper layer of Unit II. Constituents leached from Unit I are likely to precipitate in this zone, and the greater surface area provided by the finer particle sizes allow greater opportunity for silica precipitation (Chadwick et al., 1987). Unlike the calcitic concretions that are ubiquitous in the upper part of Unit II throughout the project area, duripans are only well developed in the western end of the project area, and even here they express a high degree of variability in development. Greater duripan expression in the western end may reflect greater amounts of tephra in Unit I. However, parent material differences cannot explain high variability in duripan development over distances of 10 m or less such as occur at CPP233 and CPP296.

Erosion

The other important post-depositional process at the Kennewick Man Site is erosion. Most evidence of erosion appears to be recent, i.e., within the last few decades, and associated with Lake Wallula. Downed trees, lag deposits of calcareous concretions along the shore, and the stepped profile of the streambank indicate that the terrace scarp is receding. The finer textured beds of the lower lithostratigraphic unit are more cohesive and resistant to erosion and form a stepped profile along the bank at the skeleton locality. This varies, however, as upstream sections of the terrace edge develop an approximately vertical face. Where the profile is stepped, it is likely that the bank is retreating via gradual backwasting. This may involve calving of blocks of sediment in the more cohesive layers of the lower lithostratigraphic unit. The main culprit in this erosion is wave activity generated by watercraft on Lake Wallula. When water levels are high, the banks are directly exposed to wave activity. A secondary mechanism for erosion is frost heaving that causes incremental sloughing of sediment, particularly in the upper lithostratigraphic unit. The effect of frost-heaving on bank retreat is considerably less than that of wave activity. Although not observed, it is possible that seasonally shallow water tables also play a role in erosion through sapping along the base of the terrace.

It is difficult to assess the rate of bank erosion along the terrace without historical survey control. Because wave activity appears to play the critical role, much of the erosion post-dates construction of McNary Dam. Analysis of historic aerial photography by WES personnel indicates approximately 15 m of lateral bank retreat since the photos were taken in 1930 (Lillian Wakeley, 1998, oral communication). This compares favorably with on-site observations of stone piles approximately 10-15 m from the present shoreline. Indicative of field clearing activities earlier this century, such piles usually mark fluvial terrace edges in the middle Columbia region.

ARCHAEOLOGICAL OBSERVATIONS

Huckleberry et al. were not directly engaged in the archaeological activities of the WES team but did inspect the cut bank for *in situ* archaeological deposits and review the actions and collections of others. The following are observations by the Huckleberry team on the methods and findings of the WES team and a brief description of the preliminary results of the analysis of a sample of shell taken from one midden deposit.

Methods

The WES team, assisted by Umatilla Tribe staff, prepared the stratigraphic control columns by scraping the face of the cut bank and screening the matrix through 1/4-inch mesh in 20 cm vertical intervals. They worked from the terrace surface to below the present beach without first cleaning the bank face and beach area of sloughed and beach-reworked sediments adhering to the face and base of the exposure. Removal of such sediments is an important preliminary step if one is to be certain that any objects recovered from a level are actually derived from that geologic position. By doing otherwise, it is possible that recovered materials may be derived from elsewhere from the bank or shore. In reservoir settings like this, lithics, shells, bone fragments, bits of wood, flat pebbles and historic debris are commonly found in a lag concentration right at the base of the cut bank. Therefore, because disturbed secondary sediment was not first removed from intact sediments of the terrace (due to regulations imposed in the USACE research design), the primary context of any artifacts found in the screens cannot be determined with certainty.

Observations

Two *in situ* archaeological deposits and one lag deposit of eroded artifacts were recorded during December 1997 fieldwork. These are a pit and associated lag scatter of trash at approximately CPP080 to 085, a shell midden just east of CPP200, and a lag scatter of lithics and fire-cracked rock between 260 and 315 west. In addition, WES found lithic debris at profile CPP166.

CPP080. This find consists of a large pit approximately 1 m deep containing what appear to be bovid bones (most probably domestic cow *Bos taurus*) and a ceramic brick. The bones include at least a femur and tibia. From previous experience with farmyard trash pits, the pit may contain the remains of an entire cow. On the beach, extending from east of CPP054 to CPP090 were many fragments of vessel glass, rusted steel, ceramic tableware, and sawed food bone. Metal debris includes horseshoes, square and round nails, and machine parts.

CPP200. While inspecting the terrace edge for *in situ* archaeological deposits, Chatters observed a shell midden feature eroding out of the cut bank east of CPP200 and reported this to WES personnel. This feature was not further exposed except to take two small samples (one by the Huckleberry team, one by WES) and its full extent and internal stratigraphy (if any) cannot be commented upon. The midden lies near the base of Unit I, 10-15 cm above the upper surface of Unit II (Figure 3). At Dr. Fred Briuer's (WES) invitation, Chatters collected a one liter sample from the midden for analysis. In the process, a chunk of wood charcoal was encountered in matrix between two shells. This was shown to Briuer while still intact and submitted to him for possible radiocarbon dating.

Analysis of this shell eventually will entail taxonomic identification plus growth increment measurements to be used in determining site seasonality and shell growth rates. Thus far, only taxonomic identification has been completed. The sample contains 42 identifiable valves, including 24 *Gonidea angulata* and 14 *Margaritifera falcata*. This is consistent with a middle Holocene age for the shell midden; *Gonidea* is more common in early and middle Holocene than in late Holocene deposits on the Snake and Columbia Rivers (e.g. Lyman 1980; Chatters and Hoover 1992). Its presence as a dominant component of the mollusk fauna is indicative of an aggrading, fine-textured flood plain associated with relatively higher turbidity (Vannote and Minshall 1982) than was characteristic of the historic, pre-dam Columbia River.

CPP166. WES personnel found three stone objects while screening sediment from the base of this section, at or below the beach surface at the depth of the lower lithostratigraphic unit. Chatters inspected these items and the site of their discovery and discussed them with Briuer. The items consisted of one small flake of medium-grained basalt, one very small piece of medium-grained basalt shatter, and one angular basalt pebble. The flake and bit of shatter both had remnants of cobble cortex, indicating their origins in one or more rounded river cobbles.

Inspecting the site with Briuer, Chatters observed that there was a strong possibility that these objects were part of the beach lag deposit. After being told that one piece was found in place, he pointed out that the bank at this location contained an unusual number of rodent burrows. The burrows at beach level have been refilled with calcareous concretions, bits of wood, and, more importantly, fine sand and silt almost indistinguishable in texture and firmness from the intact alluvial sediment. The flakes were probably a part of this beach sediment and burrow infilling. Dr. Jerry Galm, a geoarchaeologist at Eastern Washington University who has worked extensively on Holocene sediments of the Snake and Columbia Rivers, also looked at the setting and was of the same opinion as Chatters. Huckleberry observed the setting with Briuer and considered the context of the artifacts to be equivocal. Because the beach sediments were not removed separately, because lag deposits concentrate at the base of cut banks in reservoir-edge settings, and because of the presence of lag materials in re-filled rodent burrows, it is inadvisable to consider these artifacts *in situ* within Unit II. The large shell midden located within 30 m upstream of this profile could readily have been the source.

Lithic Scatter at CPP260-315. A light lag scatter of lithics and fire-cracked rocks was observed on the beach at the west end of the project area. Although items extended from 260 to 315 west on the grid, most lay between 275 and 300 west. The scatter consisted of a handful of small fire-cracked rocks, approximately two dozen flakes of andesite/basalt and quartzite, one flake of jasper, and one of obsidian. In the most concentrated part of the scatter within 3 m of each other were two biface fragments of andesite (Figure 6). One is the basal portion of a projectile point with a snap fracture perpendicular to the long axis at mid-blade. The cross-section is elliptical and the surface shows signs of mechanical weathering, probably from washing back and forth on the beach. It has a straight to slightly convex base, obscured by the removal of one large chip at the base, and is unshouldered. The blade expands distally and its edges are unserrated. Edge grinding is absent. Projectile points of this leaf-shape are common in middle Holocene deposits and even occur in some cases in Early Holocene sites. The probable age range is 9000 to 4500 yrs. B.P., although the absence of edge grinding or serration argues for the later half of that range. The second object is a small portion of a blade from a projectile point or knife.

No artifacts were seen in the cut bank anywhere adjacent to the scatter. Brent Hicks, an employee of the Colville Confederated Tribes, suggested that the artifacts may have been deposited along with gravel fill in a small ditch seen at the scatter's

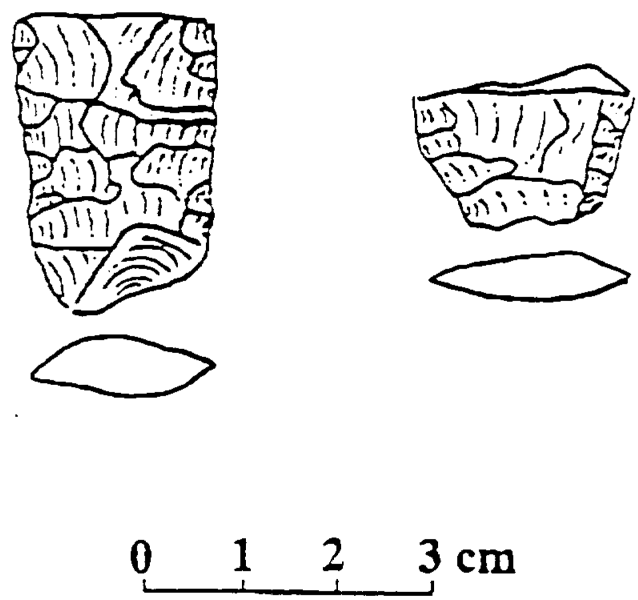

Figure 6. Projectile point fragments from lithic and fire-cracked rock scatter on beach from CPP260-315 (illustrated by James Chatters).

upstream end. If this were true, we would expect pebbles from the fill to be coterminous with the lithic scatter and the edges of the artifacts to be rounded significantly, as the gravels are. Neither of these expectations is met, leading to the conclusion that this scatter is from a local archaeological site. Further testing in the terrace tread will be needed to determine if any of this site remains and where in the stratigraphic sequence it occurs.

Discovery of Rib Fragment. On December 14, 1997, Chatters discovered a bone fragment partially buried in the beach sediments near the location of the original skeletal remains at approximately CPP062. This bone was approximately 2.5 cm by 1.5 cm and was identified by Chatters as a human rib fragment. Based upon its color and other physical characteristics, Chatters is of the opinion that the rib fragment is probably a portion of the Kennewick man skeleton. The fragment was photographed *in situ* when it was discovered, and was collected by Julie Longenecker (Umatilla personnel) and Ray Tracy (USACE) for further identification and curation.

During the December 1997 field project, only visual inspection of the beach sediments was made to locate additional pieces of the Kennewick skeleton. More active recovery techniques were not permitted by USACE. Recovery of this fragment 18 months after the initial discovery of the skeleton could indicate that the discovery location has not experienced high energy water action during the intervening period. It is likely that other parts of the skeleton remain to be recovered at the Site.

GEOLOGICAL INTERPRETATIONS

The Kennewick skeleton is associated with sediments that form an early Holocene terrace on the south bank of the Columbia River downstream from the mouth of the Yakima River. An early Holocene age is supported by tephra and radiocarbon dates in the upper 1.0 m, and by its geomorphic location which correlates with other independently dated early Holocene terraces upstream on the Columbia River (Chatters and Hoover, 1992) and on the lower Snake River (Hammatt, 1977). The lower lithostratigraphic unit (Unit II) was formed by relatively low energy, overbank deposition along the Columbia following the last of the cataclysmic Missoula floods. Although the upper beds are mixed by pedogenesis, sediments in the lower part of Unit II (> 3 m below the modern surface) record repeated sequences of fine sand grading upward to very fine sand and silt with some clay. Such repeated bedding is indicative of levee or levee-floodbasin transitional environments in meandering flood plains (Boggs, 1987: 354-358; Reineck and Singh, 1980:289-298). Each coarse-to-fine sequence probably represents discrete overbank flood events whereby the flood plain builds through vertical accretion.

Approximately 7-8 ka, the Columbia River downcut forming the terrace at Columbia Park. Subsequent to downcutting, the surface may have stabilized long enough for the formation of a soil, but soon deposition resumed as recorded by the upper lithostratigraphic unit (Unit I). Early deposition of Unit I is marked by a blanket of Mazama tephra (6.7 ka). Unlike prior deposition, aggradation was dominated by eolian sediments mixed with alluvium derived from low-order tributary streams draining the higher Pleistocene terrace to the south. There are several origins for the eolian sediment. One is sediment derived from the terrace tread, i.e., early Holocene alluvium reworked by the wind. The high frequency of *Gonidea angulata* in the mollusk assemblage from CPP200 is indicative of an aggrading, turbid Columbia River, which would have been constantly depositing new sediment on its floodplain for transport by wind. Another is from the new flood plain adjacent and inset into the terrace: annual floods would deposit very fine sands that would be easily entrained by the wind. A third source would be alluvial and lacustrine sediments derived from the Missoula floods that mantle the upland surfaces in the Pasco Basin. Except where high gradient tributaries debouch onto the project area from the higher terrace to the south, most of the sedimentation during this time was relatively quiet and low energy. When most of this deposition took place is unknown. Radiocarbon ages and the tephra indicate that much of the eolian sedimentation took place 6-7 ka, but deposition may have continued into the late Holocene. Eventually the surface stabilized, allowing for soil formation.

Soil development at the Site is fairly typical of Holocene deposits in this part of the Columbia Basin (Busacca, 1989). However, two interpretations of pedogenic history are possible. One is that Unit II contains a truncated paleosol. In this scenario, the terrace aggraded to a certain level, stabilized, and much of the calcification and silica precipitation took place. Later, the A horizon and part of the B horizon were truncated and subsequently reburied by the largely eolian Unit I. If true, then Columbia River alluviation may have ceased earlier than 7-8 ka. The alternative interpretation, and the one favored here, is that the contact between the upper and lower lithostratigraphic units is conformable, and that most of the pedogenesis took place after deposition of Unit I. Based on pedogenic development, the soil reflects at least several thousand years of surface stability. This interpretation is supported by the relatively planar contact separating Units I and II. It is unlikely that erosion of this terrace would occur by planation and leave such a laterally extensive, horizontal unconformity. It is important to note that no cut and fill structures were observed along the 345 m of streambank. Although the top of Unit II lacks an A horizon, such organic zones are seldom preserved after burial in the Columbia Basin. Instead, they tend to degrade through oxidation and may become incorporated into the B horizon of subsequent pedogenesis, i.e., become part of a composite soil (see McDonald and Busacca, 1992). However, the best evidence for this latter interpretation is the terrace soil itself. Duric features occur in the upper part of Unit II. The most probable source of silica for the duric features is the Mazama tephra, and secondary silica in Unit II could not form until after deposition of tephra in Unit I. Finally, the stratigraphic sequence seen at Columbia Park is repeated on nearly every early Holocene terrace remnant on the middle Columbia and Lower Snake Rivers, and it is unlikely that such terrace-stripping would be uniform throughout the Columbia Basin.

To summarize, the history of the terrace at Columbia Park as elucidated from streambank and sediment core stratigraphy and regional geomorphic evidence is as follows:

- Following the last Missoula flood (circa 13 ka), the mid-Columbia and lower Yakima Rivers aggrade and then downcut forming a latest Pleistocene terrace containing Glacier Peak tephra (11.2 ka; Chatters, n.d.). This terrace is not preserved at Columbia Park.
- Following 11.2 ka , the project area is characterized by episodic vertical accretion in a marginal levee-flood basin environment.
- Columbia River downcuts prior to 6.7 ka forming the terrace.
- Resumed deposition on the terrace by primarily eolian sedimentation (both reworking of alluvium and external sources) with some alluviation from ephemeral tributaries draining higher terraces; sedimentation takes place over the course of approximately 2-3 ky based on soil formation.
- Surface stability and main episode of soil development approximately 4-5 ka to present.
- Diversion of irrigation water onto and agricultural development of the terrace beginning after 1892.

- Creation of Lake Wallula and episodic retreat of the terrace scarp.

IMPLICATIONS TO SKELETAL REMAINS

The human skeleton was found scattered along the reservoir shoreline from approximately CPP057 to CPP093. The skull is reported to have been found at CPP058 to 059, approximately 4 m off what was then the shore. All skeletal materials were recovered within 7 m offshore. Approximately 90% of the recovered skeletal remains, including the oss innominates, femora, tibiae, humeri, forearm bones, complete vertebrae, and larger rib fragments came from a roughly 30 m^2 area between CPP057 and 068. Small rib fragments and bones of hands and feet were scattered in the beach lag from CPP057 to CPP 093. Many of the smaller bits were washed up against the cut bank along with carbonate concretions and historic artifacts.

Given that the bank is retreating through vertical calving, it is probable that the skeleton eroded out of the streambank during the periods of high runoff during late Winter 1996. Based on the presence of calcitic concretions on the long bones of the skeleton, the skeleton was most likely contained in one of the finer textured units located in the upper part of Unit II. These are the same calcitic concretions that form root casts as a product of pedogenesis and that are common in the finer textured strata of Unit II. At CPP054, these units are located at 75-100 cm and 125-155 cm below the modern terrace surface (Figure 5). It is uncertain at this point which bed yielded the skeleton. It is also possible that the skeleton originated from sediments then covered by lake waters, i.e., from sediments deeper than 155 cm below the terrace surface. Nonetheless, the general stratigraphy is consistent with a 8410±60 yrs. B.P. radiocarbon age for the skeleton. Strata believed to have yielded the skeleton are all below the Mazama ash which dates 6,700 yrs. B.P. Radiocarbon dating of the skeleton and of sediments throughout Units I and II will better test the stratigraphic origin of the human remains.

The relatively fine textures of the lower stratigraphic unit support a relatively quiet, low energy fluvial environment, i.e., overbank deposition near or shoreward of a natural levee. Such conditions would be favorable for preserving the original context of archaeological materials (Butzer, 1982:101; Waters, 1992:138-143). If the skeleton was buried by natural overbank sedimentation, then there is every reason to believe that the integrity of the skeleton would be preserved. Moreover, following the downcutting of Columbia River and prior to irrigation, soil conditions would have been favorable for bone preservation. Specifically, the soils would have been characterized by slightly alkaline, well drained conditions.

CONCLUSIONS AND RECOMMENDATIONS

Geoarchaeological data and interpretations gained as a result of the December 1997 fieldwork at Columbia Park should be considered preliminary. Not all questions regarding the physical context of the skeleton can be answered at this stage of the investigation. However, the investigation has provided some answers to questions posed in the original ARPA permit submitted by Huckleberry et al. in August 1997. These discoveries include the following:

DOI 02646

Is Site consistent with the radiocarbon age of the skeleton?

Yes. Terrace sediments range from mid-Holocene to latest Pleistocene in age, i.e., from approximately 11-12 ka to 6 ka. Skeleton is older than Mazama tephra or 6.7 ka. However, radiocarbon dating of sediments above and below the hypothesized position for the skeleton are needed.

Was skeleton deposited at the Site due to an intentional burial or by other causes?

Insufficient data. However, there is no evidence that the Site is a formal burial ground. No other prehistoric features or artifacts were observed in place at the skeleton locality. The paucity of archaeological materials and other considerations discussed in this report are consistent with the hypothesis that the skeleton was buried by natural geological processes, such as overbank alluviation, and it was not a deliberate burial.

Has the Site been affected by geological, biological or cultural factors following initial deposition of the skeleton?

Yes. Post-depositional processes include soil formation (bioturbation, translocation of silica and calcium carbonate) and erosion. However, pedogenesis was not strong enough to have significantly modified the skeleton physically or chemically (except perhaps to promote preservation through precipitation of carbonate around it). In 1996, the skeleton was probably exposed by vertical calving of the bank due to wave activity on Lake Wallula.

What factors may have contributed to preservation of the skeleton over time?

Low energy, overbank deposition would have covered the skeleton with fine grained, relatively impermeable, alkaline sediments. The fine-textured sediments encasing the skeleton limited downward percolation of surface water and inhibited leaching of calcium carbonate in the bones. Well drained, alkaline conditions following the downcutting of the Columbia River just prior to 6.7 ka would have also favored preservation of the skeletal materials. Well drained conditions only changed approximately 100 years ago with Anglo-European irrigation that lead to local saturation and leaching.

Was there human occupation of the Site during, prior to, or following deposition of the skeleton?

There is insufficient data to address human occupation prior to deposition of the skeleton. However, there is no evidence of prehistoric occupation at the Site during or after deposition of the skeleton. Aside from an Anglo-European historic trash deposit, there were no in situ cultural materials identified at the skeleton locality. The closest buried cultural feature was a shell midden dating approximately 6.1 ka (based on radiocarbon dated shell) in Unit I 150 m upstream.

Is the Site subject to any unusual conditions that might affect the reliability of radiocarbon dates taken from the skeleton or other organic materials?

No evidence of unusual conditions that would affect radiocarbon dating were observed. However, plans by the USACE Walla Walla District to seal the bank with organic and geological rip-rap would compromise the reliability of future ^{14}C dating of sediments (see below).

The skeleton known as "Kennewick Man" is of tremendous scientific importance given its early Holocene geologic age, its excellent physical and chemical preservation, and its non-Mongoloid morphology. The skeleton is the oldest and most well preserved from the Pacific Northwest region, and with one exception, it is the most complete and well preserved of any Paleoindian skeleton in the United States. Studying the skeleton can provide valuable information regarding early Holocene human migrations into the New World, the genetics of these populations, the fate of these peoples, and the types of human adaptations at the Pleistocene-Holocene transition. Consequently, it is essential that all contextual information pertaining to the skeleton be adequately studied. This includes a thorough geoarchaeological investigation of the Site, of which the December 1997 reconnaissance work is the beginning. To date, the investigation proposed in the ARPA permit of Huckleberry et al. has been limited by the USACE, Walla Walla District. Still to be performed is excavation into the terrace to ascertain the three-dimensional geometry of the lithostratigraphy at the Site. Although a subsequent phase of study (termed Phase 3 by the USACE) has been suggested, no details have been given when and if such activities will take place.

More data are critically needed to fully assess the geology of the Kennewick Man site. For example, the terrace chronology is based on two radiocarbon dates on shell and one chemical analysis of tephra from Unit I. These samples were collected from 50 to 300 m away from the skeleton locality. Such long-distance stratigraphic correlations require more knowledge of the deposit's geometry be known. This requires access to stratigraphy both parallel and perpendicular to the streambank. If after excavations into the terrace, no cut-and-fill channels are evident, then there can be greater confidence that geological strata can be traced across the project area. Excavations would also provide pristine exposures of Units I and II thereby providing greater confidence in the integrity of sediments for granulometric and chronological analysis. Although a rudimentary chronology exists for the Site, both age precision and accuracy need to be improved significantly to confidently place the skeleton in its correct temporal context.

Given what is known at the Site, the following recommendations are made:

1) Phase 3, test excavations in the Site's Holocene terrace, should be performed as soon as possible. This would involve the hand excavation of a geoarchaeological trench perpendicular to the bank at or near CPP054. This trench would be approximately 15 m long, 1 m wide and 1.5 to 2.5 m deep. The trench should be excavated while the streambank is exposed to better trace the stratigraphy inland. Additional subsurface information should be obtained through hand augering throughout the terrace and especially 50 m west and east of the skeleton's discovery site. This information can be used to identify depositional facies and test the interpretation that Unit II represents a levee-flood plain deposit

2) Further laboratory analyses of sediments should wait until Phase 3 excavations are completed and a final data set is established. Selection of samples for accelerator mass spectrometry (AMS) radiocarbon dating and granulometric analysis requires careful consideration of which samples would best answer the research questions. Analyses to be performed include 1) granulometry of continuous samples collected from Units I and II, including sediments within the Vibracore sections, 2) microprobe analysis of tephra collected from the skeleton locality to confirm its equivalence to the Mazama tephra, and 3) AMS dating of sedimentary organic carbon (decalcified sediment, humic and fulvic acids, and humins) from the entire stratigraphic section. Although the stratigraphy suggests otherwise, it is possible that the contact between Units I and II is disconformable, and dating could establish the presence of an erosional event. Also, it is unknown what age range is present for Unit II sediments exposed in the river bank and those from the Vibracores. The sediments must be dated to establish their chronological relationship to the age measured directly on the human skeleton. Several different chemical fractions must

be dated from the fluvial sediments to assess residence times and apparent ages for the various phases of sedimentary carbon (Muhs et al. 1997a,b).

3) The Kennewick Man skeleton should be dated by exhaustive AMS radiocarbon methods to conclusively establish its age. The single date measured so far is insufficient to establish a definitive geologic age. Complete dating will include AMS measuring of approximately 10 additional ages, on different chemical fractions of the bone, including decalcified collagen, KOH-extracted collagen, gelatin, XAD-purified total amino acids, the individual amino acids aspartate, glutamate, glycine, alanine, proline, and hydroxyproline, and possibly the carbonate apatite fraction. These protocols follow research protocol of Stafford et al. (1991) for establishing definitive ages for fossil bone samples.

4) Preliminary granulometric analysis by Alan Busacca of the Department of Crop and Soil Science, Washington State University, of sediments extracted from concretions on the long bones of the skeleton indicates that the sediments generally match one of the two fine-textured strata in the upper part of Unit II. Tests should be performed to determine which stratum contained the skeleton. This could be accomplished by collecting more sediment off the skeleton for granulometric and mineralogical analyses and comparing to sediments collected from the two strata in the field.

5) Because further scientific investigation of the Site is needed, it is strongly recommended that the site *not* be buried by rip-rap. The USACE Walla Walla District has proposed stabilizing the discovery bank area by using a combination of rock fill, topsoil, and coir fiber logs and twine. Such materials will seriously compromise the geochemical integrity of the sediments at the site, and will introduce exotic organic carbon contaminants that will preclude accurate ^{14}C dating of organic carbon associated with the terrace sediments. Burying the Site will also prevent bank sediments from being traced inland when Phase 3 proceeds. Finally and of great concern, is that Site "stabilization" will forever prevent missing skeletal fragments from being recovered. It is recommended that an alternative strategy be employed to reduce bank erosion at the Site. Instead of sealing the streambank, a simple crescentic coffer dam composed of rock material could be constructed offshore. This could be accomplished by forming a low berm around the shore. This would effectively abate wave erosion to the shore and at a fraction of the cost of the existing proposed bank stabilization project (estimated at approximately $250,000 by the USACE).

DOI 02649

STUDY RESTRICTIONS

Our research in December and the conclusions presented in this report were accomplished despite strictures that we felt unnecessary for a scientific study of this importance. Our data collecting at the site was hampered by USACE restrictions on the tests and procedures that could be conducted. These conditions were imposed for legal, not scientific reasons and therefore were a hindrance to following proper and accepted scientific protocols. The greatest hindrances to proper scientific investigations were:

1) We recommended that sediment exposures be spaced at no more than ten meter intervals. Such a pattern is consistent with sound scientific techniques and was particularly appropriate in this situation, given the nature of the geomorphology involved, the research questions to be addressed, and the unique scientific importance of the

Kennewick Man discovery. We were overruled and the exposures were placed at intervals of 10 to 40 meters.

2) A number of locations that we selected for sediment exposures were rejected by USACE. Instead, sediment exposures were made only at those locations selected by the Corps and Tribal representatives. We do not consider these locations to be either optimal or adequate for appropriate data recovery.

3) We recommended that a continuous 50 meter exposure be made and described at the locations where the skeleton was discovered. Such a continuous exposure was needed to obtain accurate information concerning the lateral dimensions and nature of the strata at this critical location. Our request was denied because of objections from Tribal representatives and instead, we were limited to 50 to 100 cm wide exposures at intervals of approximately 10 to 30 meters.

4) We requested permission to make a continuous, cleaned profile on the bank between CPP044 and CPP093 to examine and map the stratigraphy. The data would have been important for correlating the tephra horizon with the sediment horizon yielding the skeletal remains, and in determining whether or not the strata were continuous at this part of the site. Due to Tribal objections, we were allowed to clean only approximately 15 of the 49 meters along this bank face.

5) Descriptions of sediment exposures are customarily made by using vertical or as close to vertical profiles as possible. Due to Tribal objections, exposures were limited to planes parallel to the slopes existing naturally at the bank (some at 45° or less)

6) We requested permission to use the USACE Vibracore for making a continuous 2 to 3 meter long sediment core in the terrace immediately above the location near where the skeleton was discovered (approximately CPP057). Such a core would have provided important information concerning the stratigraphy of this critical location and especially, uncontaminated samples for lithology and radiocarbon analyses. Permission was denied due to USACE attorneys based on Tribal objections.

7) We were not allowed to complete our soil sample collecting from exposures at CPP080. The decision to prohibit this sampling was made by government attorneys, with the reason given being that sampling required presence of the Principal Investigators (Wakeley and Huckleberry). Such a restriction is not customary in scientific projects of this kind.

As a result of these restrictions, we were not able to obtain all of the data that could (or should) have been obtained for the project, especially concerning geologic age, archaeological potential, and stratigraphic relationships. USACE restrictions on our studies were not in keeping with customary scientific practices and appear to have been imposed because of Tribal objections or other non-scientific reasons. We were told by USACE representatives that the Tribes consider the site to be sacred and that they objected to any disturbance of the site by us. Tribal objections were specifically given for the restrictions described in items 3, 4, 5 and 6 above.

Another restriction placed by USACE was on data sharing. The USACE Draft Scope of Work for this project promised that the work would "... proceed appropriately in an open forum, with sharing and discussion of data." (see Draft Scope of Work, section 6.) Unfortunately, data sharing by the Corps was less than open or appropriate for a scientific project of this importance. Among other things, we were not provided by the

Corps with copies of Dr. Briuer's report dated December 26, 1997 and Dr. Nicken's Declaration dated January 15, 1998. One of our team members specifically asked for any reports prepared by Dr. Briuer and was informed that the Corps would not release information on a piece-meal basis. We later learned that copies of these documents were sent to the State of Washington Office of Archaeology and Historic Preservation, from whom we ultimately obtained copies shortly before this report was prepared.

The obstacles placed on our study of this site do not appear to be attributable to the USACE scientists and we wish to acknowledge the many courtesies they extended us and the cooperative and professional manner they displayed during the project. The difficulties we encountered appear to be attributable solely to their superiors.

FINAL CONCLUSIONS

1) The data obtained thus far are consistent with the hypothesis that the Kennewick Man's remains seem to have been deposited and covered at the Site by natural forces, such as a flood event. No evidence was found for the site being a burial ground.

2) Restrictions placed on the Huckleberry team prevented the use of commonly accepted geoarchaeological procedures and resulted in the loss of data, the full extent of which can not be measured until the research project described in our permit application has been completed.

3) Beach sediments should be sieved and otherwise examined in great detail for the missing skeletal fragments of the Kennewick Man. Because of this reason, and the finite possibility that the skeleton could have originated in deeper sediments, it is imperative that the bank stabilization proposed by the Corps be halted. Burying the discovery site will cause irreparable loss of scientific data.

4) Radiocarbon dating of the entire stratigraphic sequence is needed to identify erosional events, measure depositional rates, and establish if ages directly on sediments are the same or different as those from radiocarbon dating the human skeleton.

5) Formal test excavations in the terrace, as Phase 3, should proceed immediately. These test excavations are the only suitable means to examine the areas sedimentary geometry and establish whether or not the site is strictly a geological event or if there is an anthropological component.

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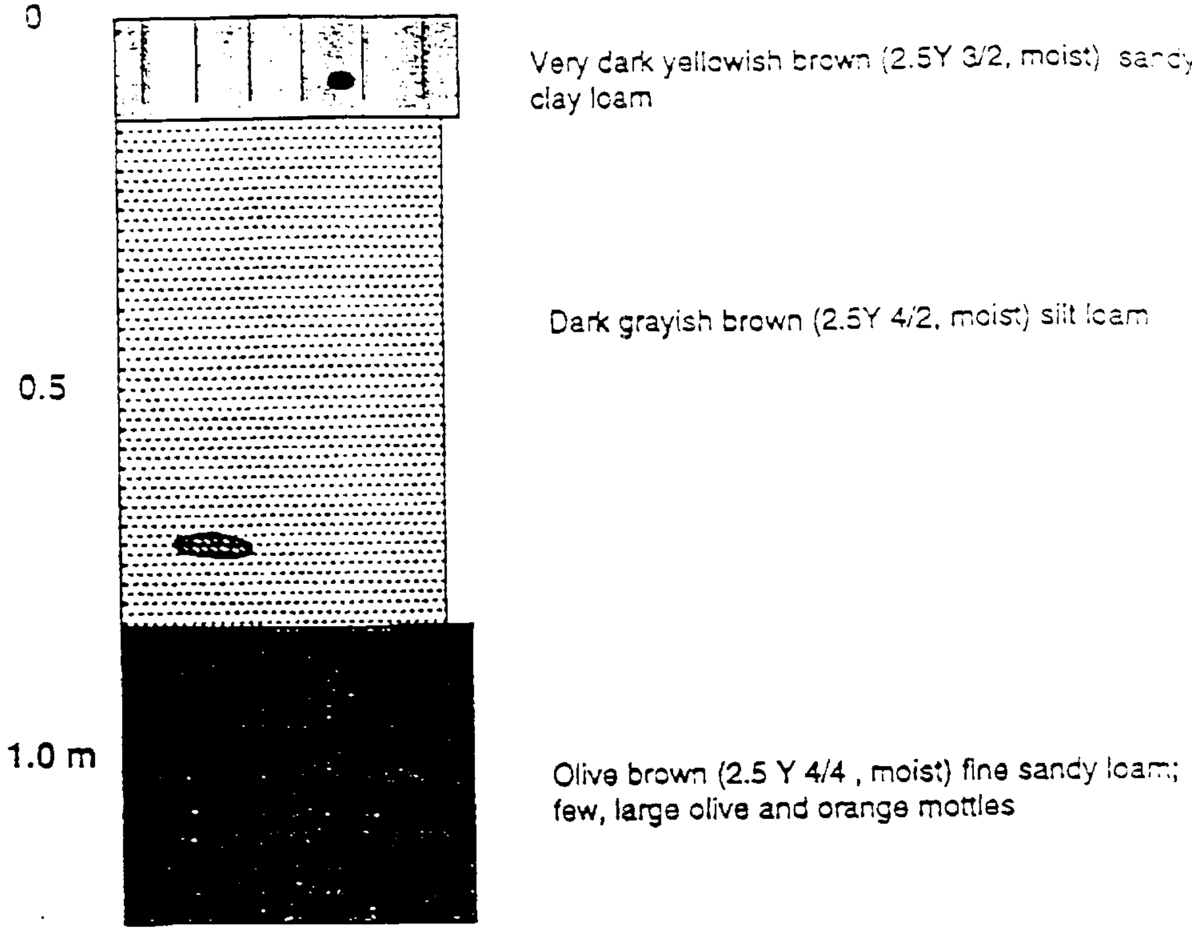
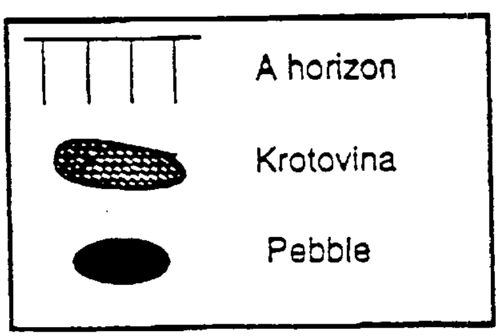
DOI 02654

APPENDIX A: STRATIGRAPHIC CONTROL COLUMN DESCRIPTIONS

Stratigraphic Column CPP005

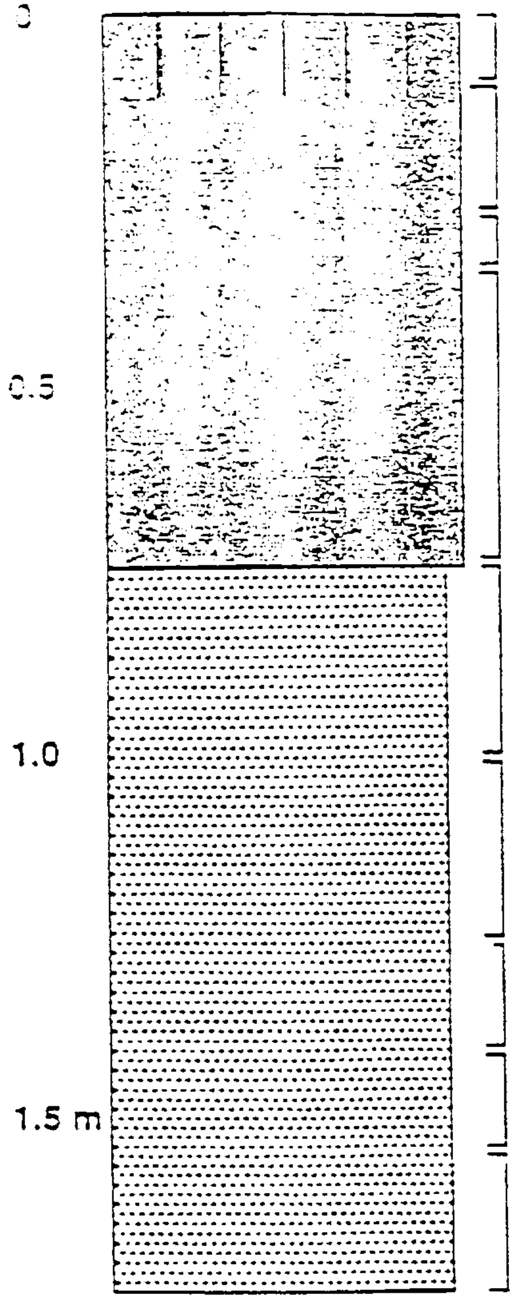
(Recorded by Gary Huckleberry and Michelle Ross)





Stratigraphic Column CPP044

(Recorded by Thomas Stafford)



Very dark brown (10YR 2.2, moist) clayey very fine sand; moderate, subangular blocky, soft peds; 3-4%, 1-2 mm diameter modern rootlets.

Brown (10YR2.2, moist) silty very fine sand; massive with 1% angular, 1-1.5 mm fragments of very dark brown clayey sand included bybioturbation.

Olive brown (10YR4/4, moist) silty very fine sand; slightly firm to soft with extremely weak, 5 mm subangular blocky structure.

Dark yellow brown (10YR4/4, moist) silty very fine sand; soft, massive; silt content increases upward; color at base is olive gray (2.5Y4/4, moist); ~~34-44~~ mm, very faint, 4-5% mottling by dark yellow brown (10YR4/4, moist).

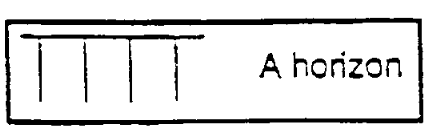
Olive brown (2.5Y4/4, moist) clayey silty very fine sand; soft to sightly firm; mottled 10% with dark yellow brown (10YR4/4, moist); 75-83 cm, 3-5% carbonates occuring as .5-1.0 mm diameter, cylindrical to tubular concretions; 83-89 cm, 10-12% carbonates occurring as 1-11 mm diameter irregular concretions; 89-100 cm, 2-3% carbonates occurring as .5-1 mm diameter root casts.

Olive brown (2.5Y4/4, moist) silty very fine to fine sand, soft, massive; beds fine upward; silty very fine to fine sand at top; 10-15% dark yellowish brown (10YR4/4, moist) mottling.

Olive brown (2.5Y4/4, moist) clayey silty very fine sand; soft, extremely weak subangular blocky structure with 2-3%, 0.5-1 mm diameter, faint, ovoid carbonate.

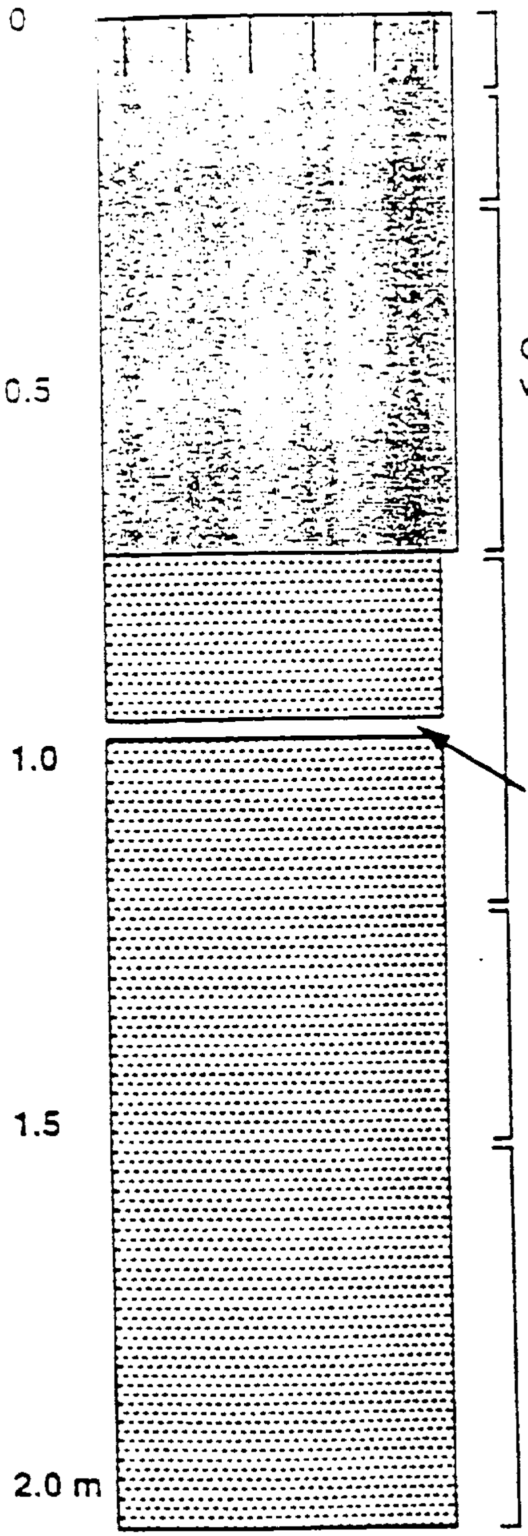
Dark grayisn brown (2.5Y4/2, moist) clayey silty very fine sand; soft, extremely weak, 3 mm angular blocky to massive structure.

Dark grayish brown (2.5Y4/2, moist) clayey very fine sand; slightly firm, massive.



Stratigraphic Column CPP054

(Recorded by Gary Huckleberry)



Very dark grayish brown (2.5Y3/2, moist) loamy fine sand.

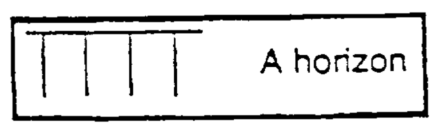
Olive brown (2.5Y4/4, moist) sandy loam.

Olive brown (2.5Y4/4, moist) loamy fine sand; few, very fine, concentrations of tephra

Olive brown (2.5Y4/4, moist) silt loam; common, very fine, white (2.5Y8/2, moist) mottles; common, medium, irregular carbonate concretions.

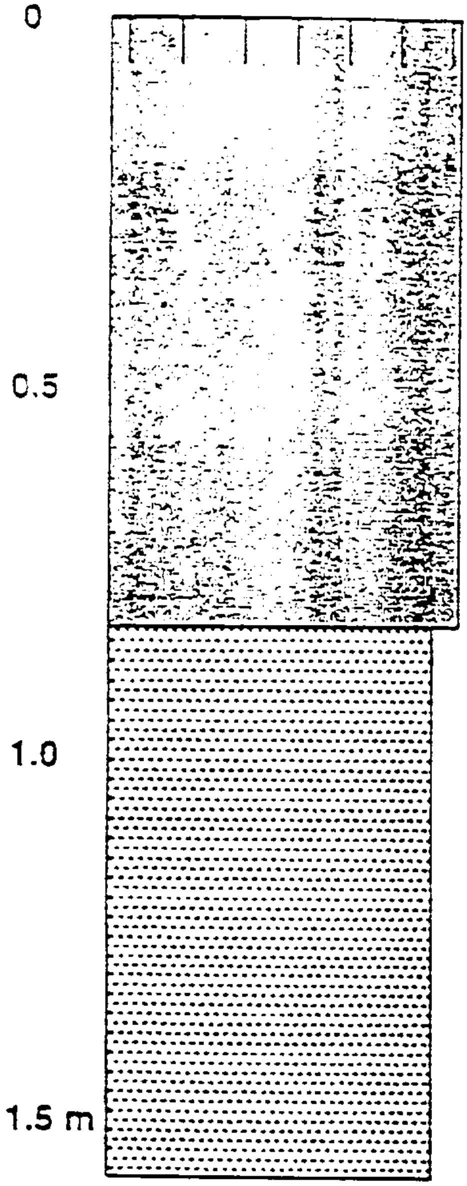
Olive brown (2.5Y4/4, moist) silt loam; few, very fine, white (2.5Y8/2, moist) mottles.

Olive brown (2.5Y4/4, moist) loamy fine sand.



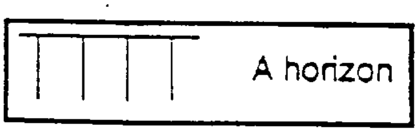
Stratigraphic Column CPP080

(Recorded by Gary Huckleberry and David Johnson)



Olive brown (2.5YR4/4, moist) loamy fine sand; few, fine, white (2.5Y8/2, moist) mottles (tephra) 20-30 cm below surface.

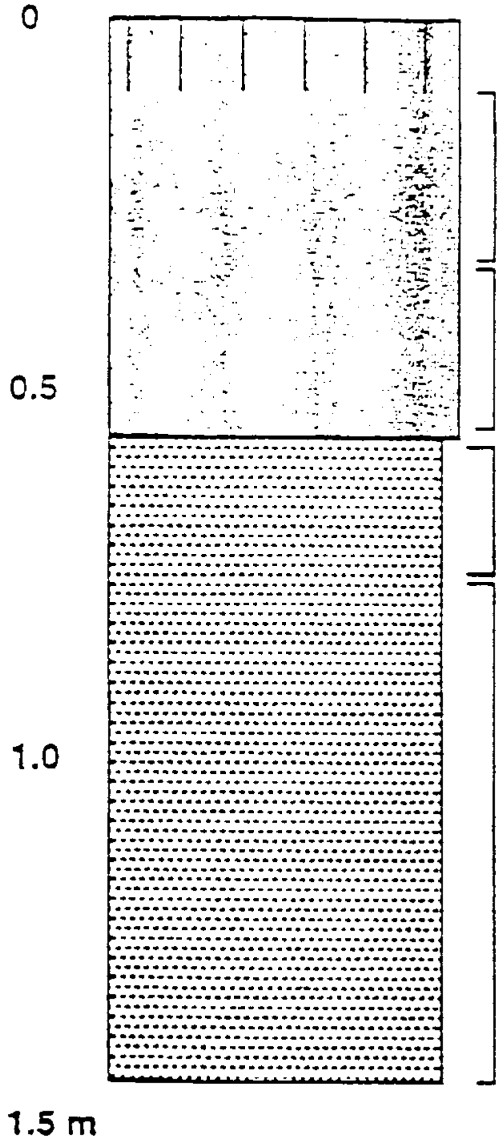
Olive (5Y4/4, moist) silty loam; few, medium irregular concretions of carbonate.



DOI 02659

Stratigraphic Column CPP093

(Recorded by Gary Huckleberry and David Johnson)



Very dark grayish brown (2.5Y3/2, moist) loamy fine sand.

Olive brown (2.5Y4/4, moist) loamy fine sand.

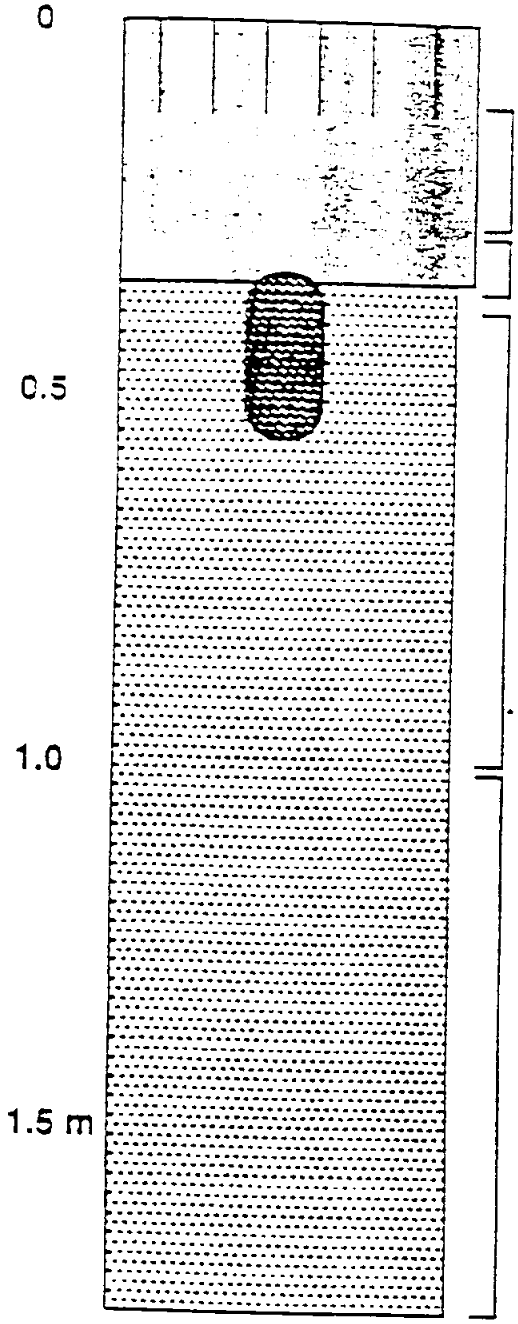
Olive brown (2.5Y4/4, moist) sandy loam; many, medium, irregular white (2.5Y 8/2, moist) mottles (tephra) 30-38 cm below surface.

Olive brown (2.5Y4/4, moist) silt loam.

Olive brown (2.5Y4/4, moist) sandy loam.

Stratigraphic Column CPP125

(Recorded by Diane Curewitz, Jonathan Danz, and Gary Huckleberry)



Dark brown (10YR3/3, moist) sandy loam; slight effervescence.

Dark grayish brown (2.5Y4/2, moist) sandy loam; slight effervescence.

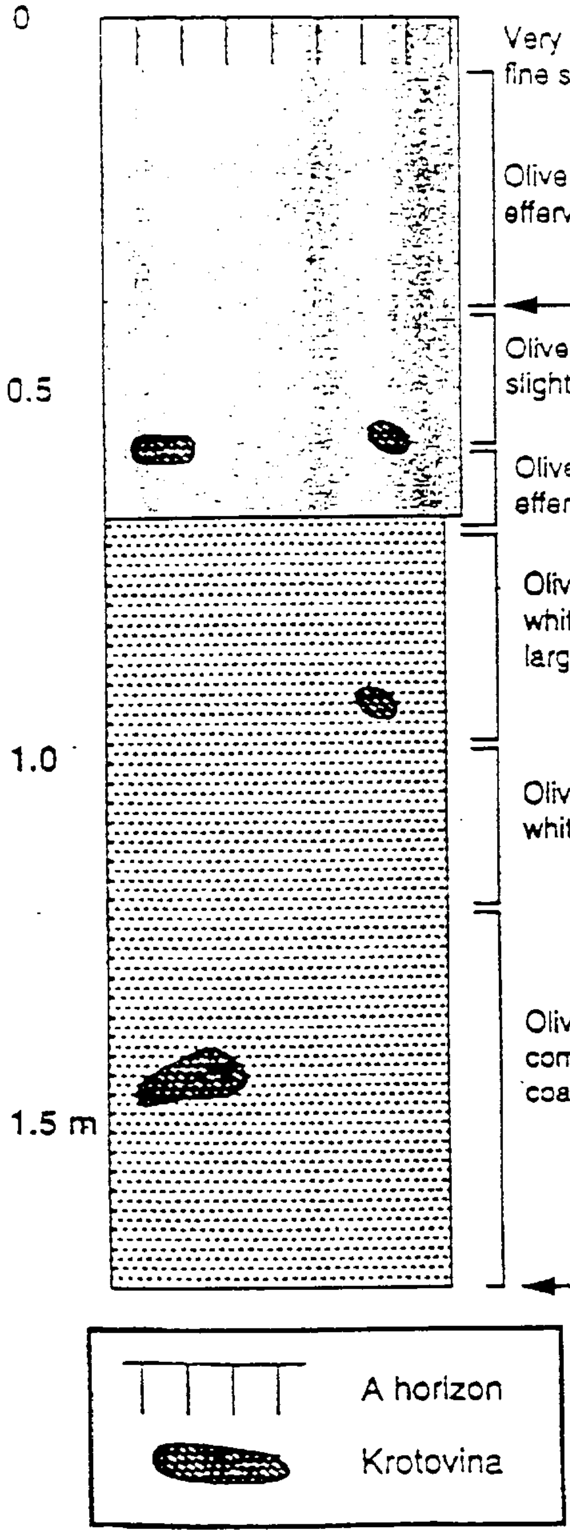
Dark grayish brown (2.5Y4/2, moist) sandy loam with common, fine pale yellow (2.5Y7/4, moist) mottles; few, medium concretions; strong effervescence.

Dark grayish brown (2.5Y4/2,moist) silty clay loam with common, fine pale yellow (2.5Y7/4, moist) and yellowish brown (10YR5/8, moist) mottles; common, medium to large concretions; slight to strong effervescence.

Olive brown (2.5Y4/4, moist) silt loam with many, fine dark yellowish brown (10YR4/6, moist) mottles; strong to violent effervescence.

Stratigraphic Column CPP166

(Recorded by Gary Huckleberry)



Very dark grayish brown (2.5Y3/2, moist) loamy fine sand.

Olive brown (2.5Y4/4, moist) loamy fine sand; slight effervescence.

few flecks of shell

Olive brown (2.5Y4/4, moist) loamy fine sand; very slight effervescence.

Olive brown (2.5Y4/4, moist) loamy fine sand; slight effervescence.

Olive brown (2.5Y4/4, moist) silt loam with few, white (2.5Y8/2, moist) mottles; common, medium to large, irregular concretions; slight effervescence.

Olive brown (2.5Y4/4, moist) silt loam with few, fine, white (2.5Y8/2, moist) mottles; slight effervescence.

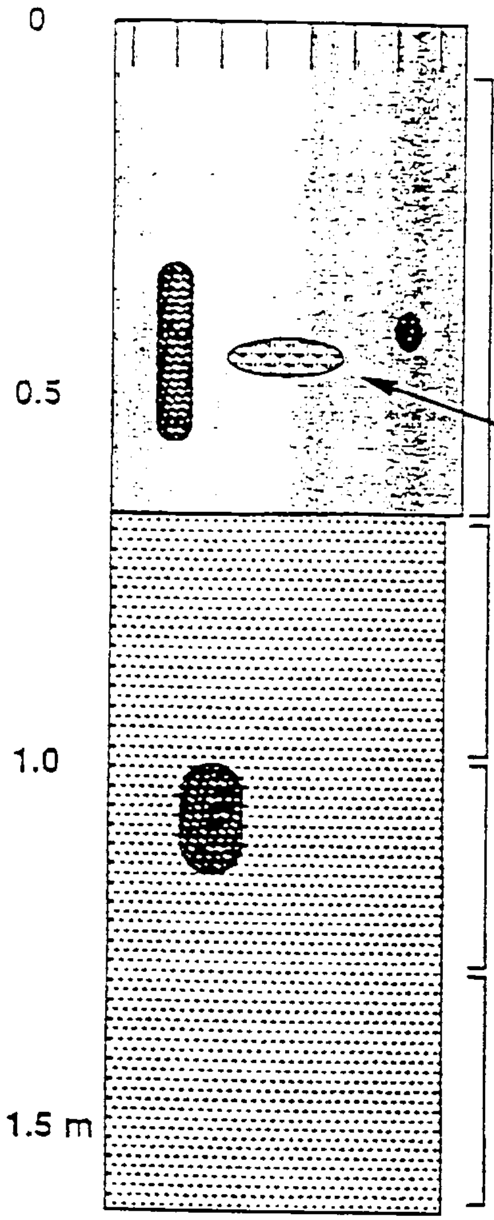
Olive brown (2.5Y4/4, moist) silt loam with common, dark reddish brown (5YR3/3, moist) coatings on ped faces; very slight effervescence.

Three flakes recovered from base of column

DOI 02662

Stratigraphic Column ~CPP200

(Recorded by Gary Huckleberry and David Johnson)



Very dark grayish brown (2.5Y3/2, moist) loamy fine sand; slight effervescence.

Olive brown (2.5Y4/4, moist) loamy fine sand; slight effervescence.

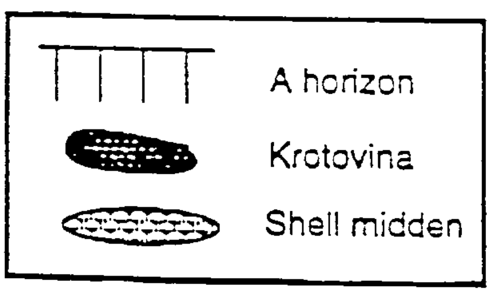
(Shell midden extends > 2 m to the east)

6,090–80 C14 yr B.P. (Beta-113838)

Olive brown (2.54/4, moist) silt loam with common, medium to coarse, irregular white (2.5Y8/2, moist) mottles; moderate, medium, angular blocky structure; slight effervescence.

Olive brown (2.54/4, moist) silt loam with common, fine, irregular white (2.5Y8/2, moist) mottles; no structure; no effervescence.

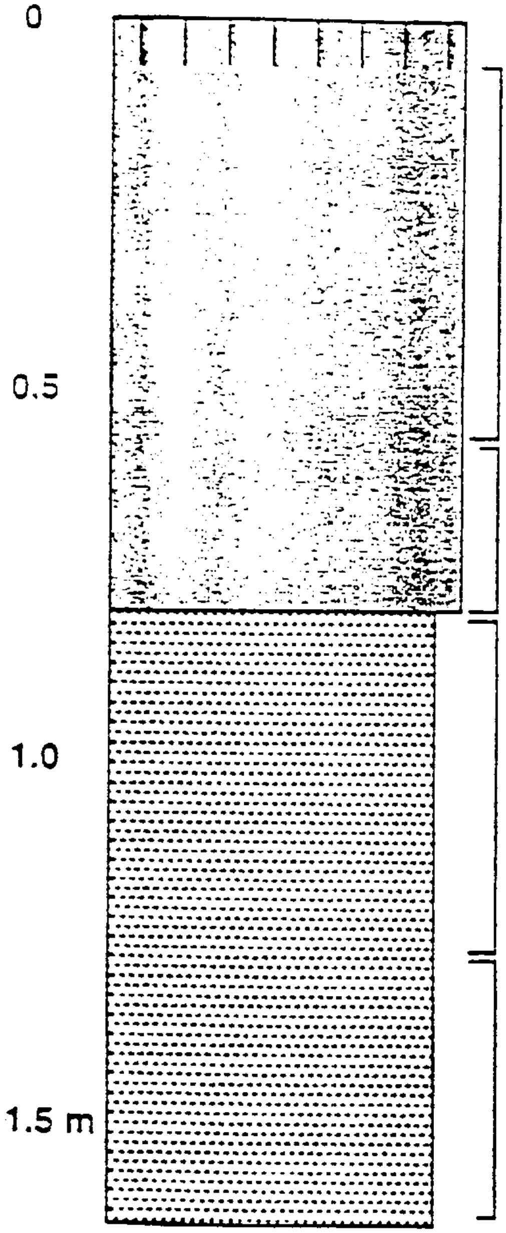
Olive brown (2.54/4, moist) silt loam; no structure; no effervescence.



DOI 02663

Stratigraphic Column CPP233

(Recorded by Gary Huckleberry and David Johnson)



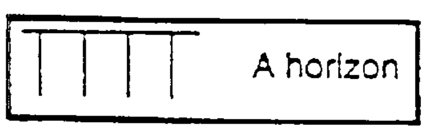
Dark brown (10YR3/3, moist) fine sandy loam.

Olive brown (2.5Y4/4, moist) fine loamy sand.

Light olive to olive brown (2.5Y4.5/4, moist) fine loamy sand; few, medium to lare, irregular concretions; slight effervescence.

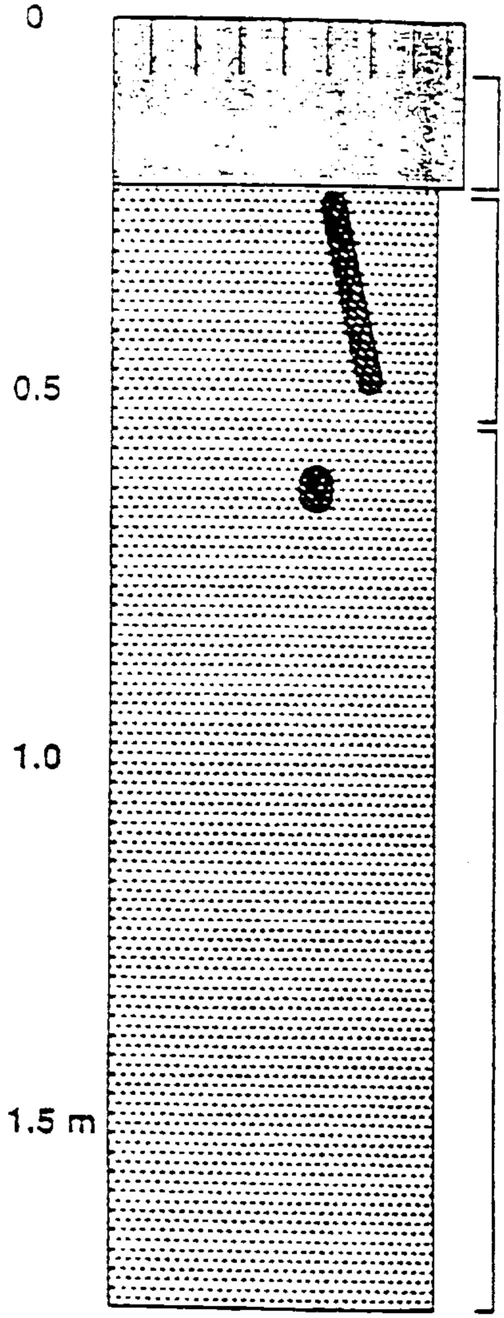
Light olive to olive brown (2.5Y4.5/4, moist) silt loam; common, medium to large, irregular concretions; slight effervescence.

Olive brown (2.5Y4/4, moist) silty clay loam.



Stratigraphic Column CPP268

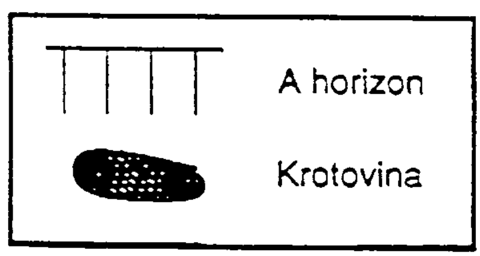
(Recorded by Amy Holmes, Kathryn Kramer, and Gary Huckleberry)



Very dark grayish brown (10YR3/2, moist) sandy loam; very slight effervescence.

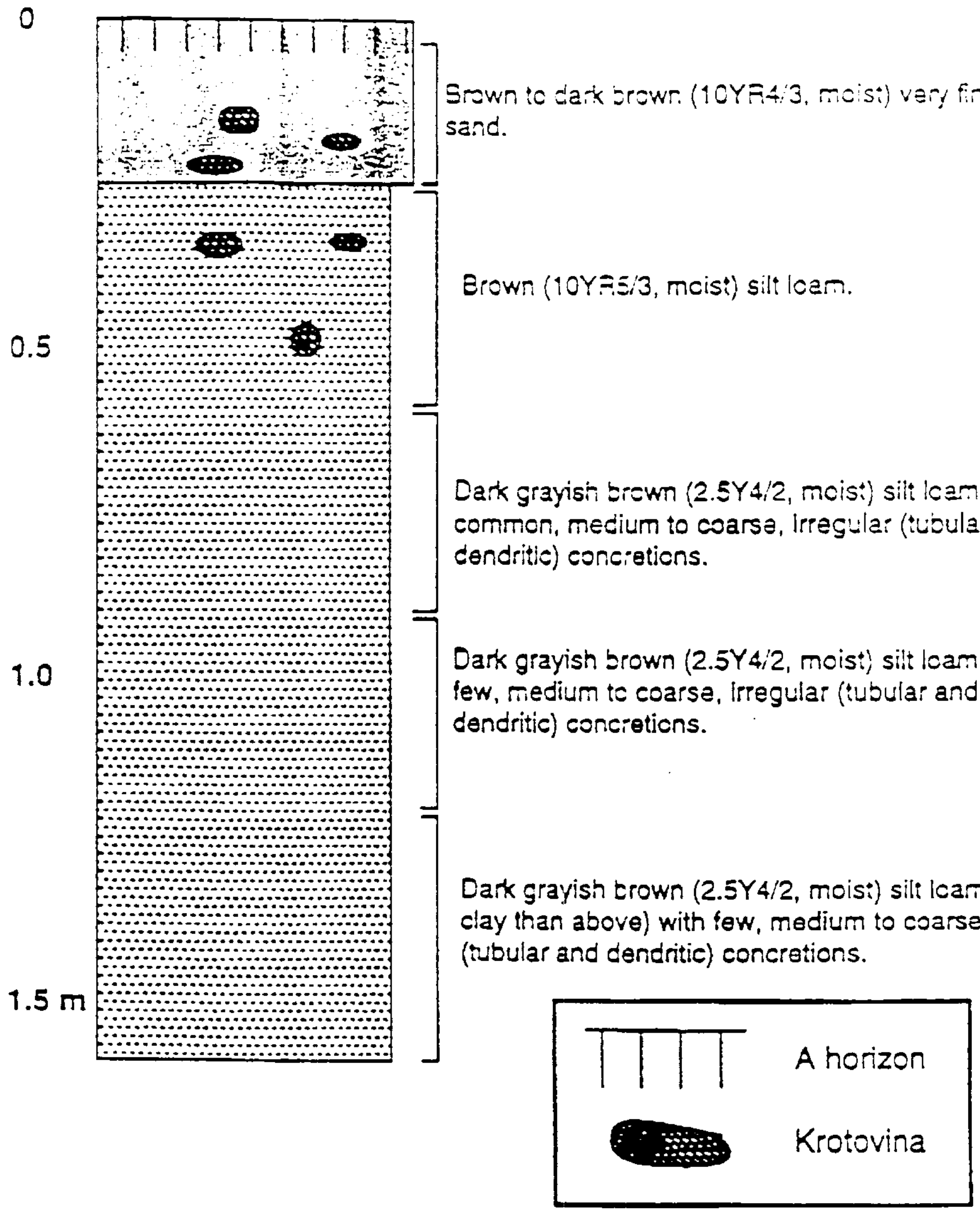
Brown (10YR5/3, moist) silt loam; few, coarse concretions; strong effervescence.

Brown (10YR5/3, moist) silt loam and silty clay loam; few, coarse, concretions; strong effervescence.



Stratigraphic Column CPP296

(Recorded by Gary Huckleberry, Robson Bonnichsen, and Donald Wysocki)



Brown to dark brown (10YR4/3, moist) very fine loamy sand.

Brown (10YR5/3, moist) silt loam.

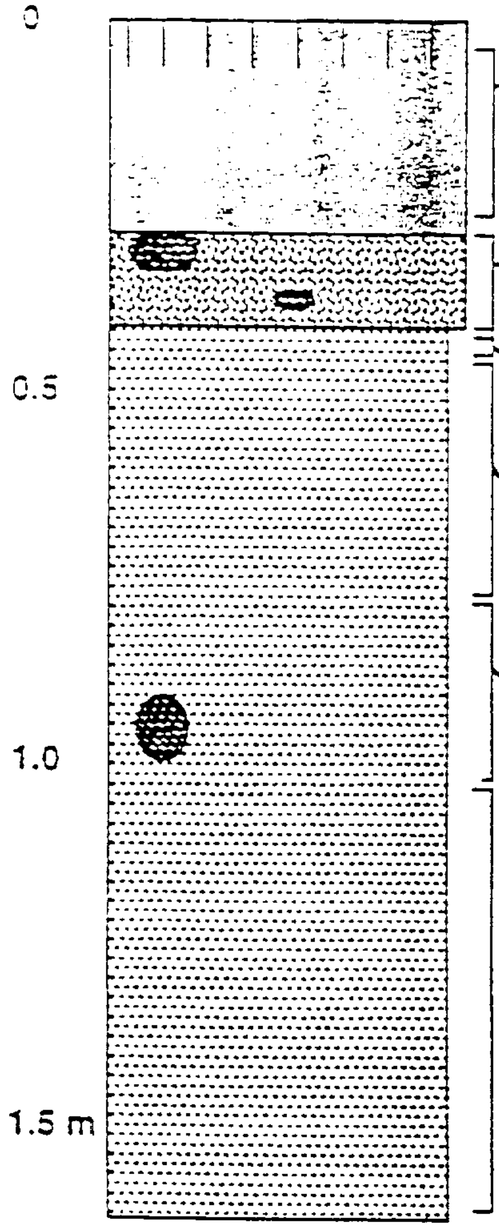
Dark grayish brown (2.5Y4/2, moist) silt loam with common, medium to coarse, irregular (tubular and dendritic) concretions.

Dark grayish brown (2.5Y4/2, moist) silt loam with few, medium to coarse, irregular (tubular and dendritic) concretions.

Dark grayish brown (2.5Y4/2, moist) silt loam (less clay than above) with few, medium to coarse, irregular (tubular and dendritic) concretions.

Stratigraphic Column CPP334

(Recorded by Thomas Stafford)



Dark brown (10YR3/3, moist) silty very fine to fine sand; massive structure; soft; irregular bioturbated base.

Pinkish gray (7.5YR6/2, moist) to light brown (10YR6/2, moist) volcanic ash; massive structure; moderately hard but locally soft to hard; bioturbated throughout; basal 4-6 mm is hard to very hard with .2-.4 mm thick, wavy platy structure.

Light olive brown (2.5Y5/4, moist) silt; hard to very hard with weak, 2mm thick X 10 mm long platy structure.

Dark brown (10YR4/3, moist) clayey silt; soft, very weak 5 mm angular blocky structyu with no carbonate in upper part and grading down to 8% faint, irregular, 1-2 mm diameter anastomosing light gray carbonate; locally very hard; 5%, .5 mm root voids.

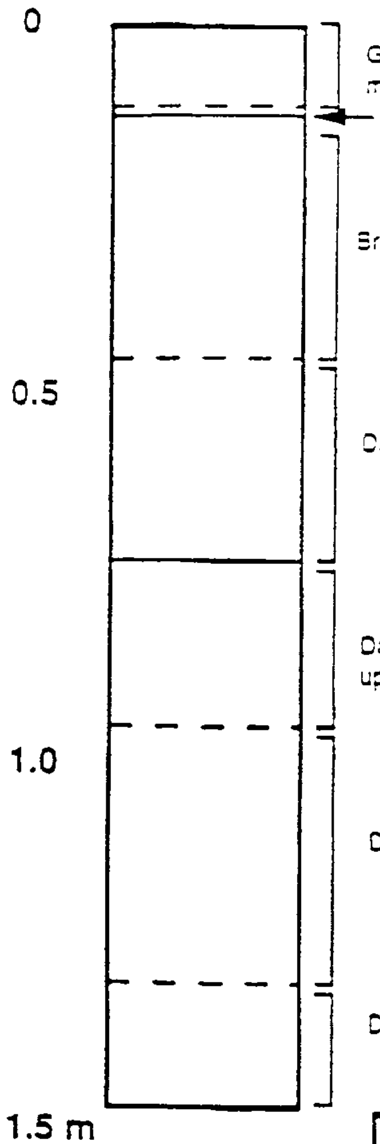
Brown (10YR5/3, moist) silt; soft, with faint, 1-2%, 0.5-1 mm diamter X 1-2 mm long, very light gray carbonate developed around root molds.

Dark brown (10YR4/3, moist) silt; soft, massive structure.

APPENDIX B: SEDIMENT CORE DESCRIPTIONS

Core CPC044

(Recorded by Gary Huckleberry, Melanie Bedell, Jonathan Meyers, and Jeffrey Rasic)



Grayish brown (10YR5/2, moist) fine sand and dark grayish brown (10YR4/2, moist) very fine sand; planar to low-angle cross bedded laminae.

Coarse sand and few granules; many granules composed of < 1 mm tubular carbonate concretions; also few rounded volcanic and quartz granules; single 1 mm amber glass shard.

Brown to dark brown (10YR4/3, moist) silt loam; crude fining upward.

Dark brown (10YR3/3, moist) silt loam; more very fine sand than above.

Dark brown to brown (10YR3.5/3, moist) silt loam; amount of fines decreases upward.

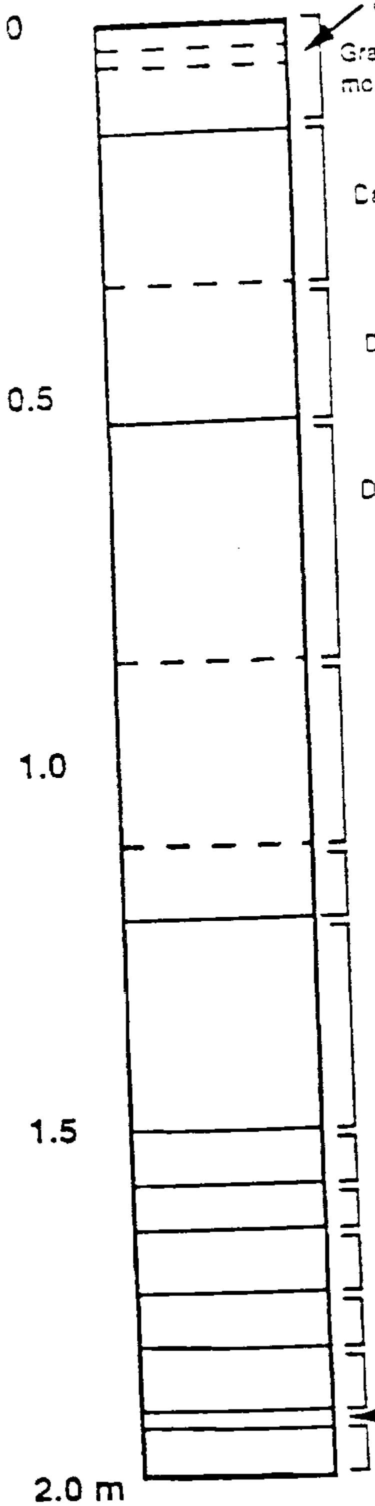
Dark brown (10YR3/3, moist) loamy fine sand.

Dark brown (10YR3/3, moist) silt loam.

——	abrupt (< 5 mm) contact
– – –	gradual (> 5 mm) contact

Core CPC054

(Recorded by Gary Huckleberry, Amy Lawrence, John Pouley, and Mathew Van Pelt)



Coarse sand with few granules of carbonate concretions.

Grayish brown (10YR5/2, moist) fine sand and dark grayish brown (10YR4/2, moist) very fine sand; planar to low-angle cross bedded laminae.

Dark grayish brown (2.5Y4/2, moist) silt loam; more fines than below.

Dark brown (10YR3/3, moist) silt loam; more very fine sand than above.

Dark brown to brown (10YR3.5/3, moist) silt loam; more fines than below.

Dark brown (10YR3/3, moist) silt loam; more very fine sand than above.

Dark brown (10YR3/3, moist) fine sand.

Dark brown (10YR3/3, moist) silt loam.

Dark brown to brown (10YR4/3, moist) very fine sand.

Dark brown (10YR3/3, moist) silt loam.

Dark brown to brown (10YR4/3, moist) very fine sand.

Dark brown (10YR3/3, moist) silt loam.

Dark brown to brown (10YR4/3, moist) very fine sand.

Dark brown (10YR3/3, moist) silt loam.

Dark brown to brown (10YR4/3, moist) very fine sand.

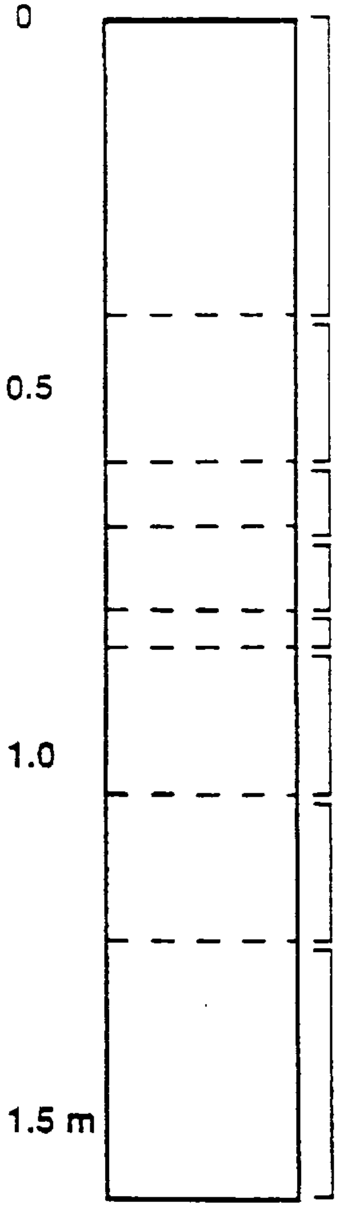
——— abrupt (< 5 mm) contact

— — — gradual (> 5 mm) contact

DOI 02670

Core CPC060

(Recorded by Gary Huckleberry, LeeAnna Gould, Kira Presler, and Sarah VanGalder)



Dark brown (10YR3/3, moist) silt loam; few, 1-7 mm, irregular calcareous concretions; common, very fine, 3-6 mm long modern rootlets.

Dark brown (10YR3/3, moist) silt loam; few, very fine, 3-6 mm long modern rootlets.

Dark yellowish brown (10YR3/3, moist) silt loam (more clay).

Dark yellowish brown (10YR3/3, moist) silt loam.

Dark grayish brown (10YR4/2, moist) silt loam (more clay).

Dark grayish brown (10YR4/2, moist) silt loam.

Dark yellowish brown (10YR3/4, moist) silt loam (more clay).

Dark brown to brown (10YR4/3, moist) silt loam (more clay).

——— abrupt (< 5 mm) contact
— — — gradual (> 5 mm) contact

DOI 02671

APPENDIX C: SOIL PEDON DESCRIPTIONS

Soil Profile KM1

Location: Benton County, WA; Columbia River shorelands in T9N, R29E, SW 1/4, SW 1/4, Section 27, right bank of the river between miles 331.5 and 332; a.k.a. Kennewick Man locality.
Physiographic Position: Alluvial terrace along the Columbia River.
Topography: Level with < .5% slope
Drainage: Highly variable; in places poorly drained.
Vegetation: *Salix* sp., assorted grasses.
Parent material: Fine-textured alluvium capped by eolian sands.
Sampled by: Gary Huckleberry, Michelle Ross, December 14, 1997.
Remarks: 6.7 m upstream from stratigraphic column CPP-296. 2Bkq2 horizon is partly cemented (duripan?). Colors are for moist conditions.

A — 0-8 cm. Very dark grayish brown (10YR 3/2) loamy fine sand; weak, medium, subangular blocky structure; very friable (moist), not sticky and slightly plastic (wet); slightly effervescent; clear, smooth boundary.

Bk1 — 8-27 cm. Brown to dark brown (10YR 4/3) loamy fine sand; massive; very friable (moist), not sticky and slightly plastic (wet); slightly effervescent; gradual smooth boundary.

2Bkq2 — 27-35 cm. Olive brown (2.5Y 4/4) silt loam; moderate, fine, platy structure; very firm (moist), not sticky and slightly plastic (wet); slightly effervescent; few, faint, waxy cutans on ped faces; clear smooth boundary.

2Bk3 — 35-57 cm. Olive brown (2.5Y 4/4) silt loam; weak, medium, angular blocky structure; friable (moist), sticky and plastic (wet); slightly effervescent; gradual smooth boundary.

2Bk4 — 57-110+ cm. Olive brown (2.5Y 4/4) silt loam with common, medium, distinct, white (2.5Y 8/2) mottles; massive; friable (moist), sticky and plastic (wet); slightly effervescent.

Soil Profile KM2

Location: Benton County, WA; Columbia River shorelands in T9N, R29E, SW 1/4, SW 1/4, Section 27, right bank of the river between miles 331.5 and 332; a.k.a. Kennewick Man locality.
Physiographic Position: Alluvial terrace along the Columbia River.
Topography: Level with < .5% slope
Drainage: Highly variable; in places poorly drained.
Vegetation: *Salix* sp., assorted grasses.
Parent material: Fine-textured alluvium capped by eolian sands.
Sampled by: Gary Huckleberry, Dave Johnson, December 14, 1997.
Remarks: Coincides with stratigraphic column CPP-233. Colors are for moist conditions.

A	0-5 cm. Dark brown (10YR 3/3) fine loamy sand; weak, fine, granular structure; loose to very friable (moist), not sticky and slightly plastic (wet); noneffervescent; gradual, smooth boundary.
Bk1	5-59 cm. Olive brown (2.5Y 4/4) fine loamy sand; massive; very friable (moist), not sticky and slightly plastic (wet); slightly effervescent; gradual smooth boundary.
Bkq2	59-79 cm. Light olive brown to olive brown (2.5Y 5-4/4) sandy loam; massive; friable (moist), sticky and plastic (wet); slightly effervescent; few, medium to large irregular concretions that slightly effervesce; gradual smooth boundary.
2Bkq3	79-126 cm. Light olive brown to olive brown (2.5Y 5-4/4) sandy loam; weak, medium, angular blocky structure; firm (moist), sticky and plastic (wet); slightly effervescent; common, medium to large, irregular concretions that effervesce slightly; few, faint, waxy cutans on ped faces; gradual smooth boundary.
2C	126-160+ cm. Olive brown (2.5Y 5/4) sandy clay loam; massive; friable (moist), very sticky and very plastic (wet); noneffervescent.

Soil Profile KM3

Location: Benton County, WA; Columbia River shorelands in T9N, R29E, SW 1/4, SW 1/4, Section 27, right bank of the river between miles 331.5 and 332; a.k.a. Kennewick Man locality.
Physiographic Position: Alluvial terrace along the Columbia River.
Topography: Level with < .5% slope
Drainage: Highly variable; in places poorly drained.
Vegetation: *Salix* sp., assorted grasses.
Parent material: Fine-textured alluvium capped by eolian sands.
Sampled by: Gary Huckleberry, Dave Johnson, Dianna Georgina, December 15, 1997.
Remarks: Coincides with stratigraphic column CPP-093. Bk2 contains reworked Mazama tephra. Colors are for moist conditions.

A — 0-9 cm. Very dark grayish brown (2.5Y 3/2) fine loamy sand; weak, medium to coarse, granular structure; very friable (moist), not sticky and not plastic (wet); noneffervescent; gradual, smooth boundary.

Bk1 — 9-30 cm. Olive brown (2.5Y 4/4) fine loamy sand; weak, medium, angular blocky structure; very friable (moist), slightly sticky and slightly plastic (wet); slightly effervescent; clear, smooth boundary.

Bk2 — 30-43 cm. Olive brown (2.5Y 4/4) silt loam with common, prominent white (2.5Y 8/2) mottles; massive; very friable (moist), slightly sticky and slightly plastic (wet); slightly effervescent; abrupt smooth boundary.

2Bk3 — 43-75 cm. Olive brown (2.5Y 4/4) silt loam; weak, medium, angular blocky structure; friable (moist), slightly sticky and plastic (wet); slightly effervescent; clear, smooth boundary.

2Bk4 — 75-140 cm. Olive brown (2.5Y 4/4) sandy loam; massive; friable (moist), slightly sticky and slightly plastic (wet); slightly effervescent.