CHAPTER IV
THE CERAMICS

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1. Introduction

Our study of the ceramic inventory excavated at Pavlov I during the 1952-53 field seasons focused on establishing what categories of objects were present as well as how they were made. The examined collection of 1,332 objects was subjected to an in-depth technological and typological analyses. Thirty nonfigurative Pavlov I ceramic samples as well as four samples of loess from the site and one recovered near a hearth at the site were subjected to the same series of laboratory analyses we had used in our study of the Dolní Věstonice I ceramics to characterize structure, composition, range of variability, and firing temperatures (for a detailed description see Vandiver et. al. 1990).

The typological study sub-divided the inventory into the following five analytic categories:

I. Not worked or smoothed

II. Worked or smoothed:

- A. Non-figurative
- B. Figurative:
  - (1) anthropomorphic
  - (2) zoomorphic
  - (3) anthropomorphic or zoomorphic

The objects in each category were counted, measured, weighed, and classified by color as yellow to tan, gray, or black. Shaped pieces were examined to determine what methods were used to fashion them. Figurative pieces were examined for the following traits:

- a. silhouette: natural; distorted - how
- b. depiction : natural; stylized -how
- c. body position : at rest; in motion - what kind
- d. decorative elements: absence; presence: nature and location
- e. damage: where, what kind

2. The Ceramic Technology

2.1. The Samples

Microscopic examination showed that one of the 30 supposed ceramic samples was weathered, stained and cracked tooth enamel and dentin. The other samples made of inorganic materials were sorted by color and hardness into three groups. One was yellow and soft (Mohs hardness of about 1 1/2 to 2). The second was gray to dark tan or black in color and slightly harder. The color tended to be splotchy, as if smudged or fire smoked. The third group was tan to brown or orange and harder (Mohs 2-3 1/2). The color tended to be layered from the exterior to the interior with tan, brown or gray on the exterior and orange on the inside.

The four samples of loess were provided as control samples and were used to establish a baseline of untreated, unworked and unfired samples during the characterization of composition, microstructure and firing reactions. Three of the samples were easily powdered and yellow. The fourth sample was orange in color and somewhat hard to crush.

2.2. Analyses and Results

To determine whether the proposed ceramic samples were durable examples of well-fired ceramic, a subsample of 50 to 80 mg. was placed in a beaker of boiling water, and a durability test was conducted. Fifteen of the 29 samples dissolved when placed in the boiling water, indicating they are not durable examples of well-fired clay. They may have rehydroxlated during burial, or they may never have been fired. The remaining fourteen samples proved durable during 3 hours of continuous boiling, and after standing in water for a further 24 hours. When dry their original color and Mohs hardness returned. All of the yellow subsamples dissolved when placed in boiling water; whereas, all of the orange subsamples remained unaltered after this test. Thus, the orange color is an indication of the upper limit of firing temperature. In comparison with the Dolní Věstonice I assemblage of ceramic fragments, those from Pavlov are less durable. Twenty-nine of 30 samples tested from Dolní Věstonice excavations remained hard and durable after undergoing the same test. As will be discussed later, such variation in properties indicates that there are differences between the two ceramic assemblages.

In order to determine whether the reason for the lack of strength of half of the ceramic fragments is related to composition or firing, a subsample of 25-50 mg. was subjected to a 2 N solution of hydrochloric acid. The tooth fragment dissolved slowly. The 15 nondurable samples and 4 of the gray to black splotchy samples in the second group fizzed rapidly, indicating the probable presence of calcium carbonate. In each case not all of the sample dissolved, indicating the presence of noncarbonate minerals. In each case, the residue upon drying was stained yellow, presumably due to the presence of iron oxide and/or hydroxide, both of which are somewhat soluble in HCl acid. From this test, our conclusion is that the reason for the lack of durability is that unsuitable, earthy materials probably high in calcium carbonate were chosen as a raw material for modeling of lumps and figurines.

In order to confirm that calcium carbonate was present and to test how much calcium carbonate made the raw material unsuitable, both spectrographic and diffraction methods were used. Another 50 mg subsample was taken from two of the yellow and two of the gray splotchy samples. These were mounted for examination with a scanning electron microscope, along with pressed pellets of well milled mixtures of reagent grade powders consisting of 25 wt% $CaCo_3$-75% SiO_2 and a 50-50 mixture. These three artificial mixtures were used as standards to compare the composition of the four unknowns. Using energy dispersive x-ray analysis in a scanning electron microscope at 200x magnification and counting for 180 seconds, the four samples were shown to one quarter to one half calcium carbonate. X-ray diffraction of the four unknowns confirmed that calcium carbonate was present, in addition to quartz and an illitic type of clay and a minor amount of mica. Other very minor peaks were present, but were not identified. Thus, we conclude that several of the fragments which appear to be clay-based ceramics were mixtures of calcium carbonate, clay and quartz.

To test whether any of the high lime clays could have formed a durable ceramic, refiring experiments were conducted, but they were unsuccessful. When the four subsamples of calcium carbonate, clay and quartz are fired in an oxidizing atmosphere to 600°C for 20 minutes after having been wetted and formed and dried, they form somewhat hard and durable ceramic if about 25% $CaCO_3$ is present, but they powder when 50% or more $CaCO_3$ is present. In the 50% $CaCO_3$ sample not enough of the clay is present to sinter to a hard body if so much powdered limestone is present. When refired to 800°C, all four samples form powder, as the $CaCO_3$ has formed CaO. The 25% $CaCO_3$ "deadburns", or does not recarbonate and harden. The 50% or more $CaCO_3$ forms the hydroxide when water is added and then recarbonates in air. Essentially, it hardens to about 2 Mohs in a mechanism similar to the formation of an impure lime plaster. None of these lime-containing samples, when refired, forms a durable, hard clay-based ceramic. All of them dissolve when subjected to boiling water.

The ten fragments of durable orange, brown and dark gray ceramic were tested by scanning electron microscopy and found to have the sintered structures commonly found in fired ceramics. The close packing of particles indicates that the body was wetted prior to forming. The amount of calcium oxide in these ceramics is less than 20%. Their compositions are similar to and lie within the range of compositions found in the ceramics from Dolní Věstonice I.

We have microprobe data for the Dolní Věstonice I ceramics, but not for the ones from Pavlov. However, our conclusion of quantitative compositional similarity is based on similarity in the energy-dispersive x-ray spectra. The semi-quantitative analysis of the spectra for the Dolní Věstonice I and Pavlov I ceramics were taken and compared with instrumental standards using the same measurements of background and in the same analysis session. The Faraday cup was monitored for beam current drift, thus insuring constancy of instrumental parameters. Our conclusion is that 10 successful ceramic fragments from Pavlov I have a similar microstructure and bulk composition to those from Dolní Věstonice I.

Differential thermal analysis was used to determine the extent of firing. The firing standards developed for the Dolní Věstonice I ceramics were applied to those from Pavlov I. The use of the same standards was justified because of the similarities of composition, microstructure and properties. The Dolní Věstonice ceramics were fired from 600°C to 800°C. DTA curves for the 10ceramic samples and one hearth sample were superimposed onto the curves from the Dolní Věstonice study, as were curves for the three unfired loess samples and unfired yellow lump samples. The unfired samples have a large, endothermic decomposition curve in the range of 620° to 820°C. This curve is a composite of the decomposition reactions for calcium carbonate, muscovite mica, illite and chlorite (clinochlore), as demonstrated in a previous publication (Vandiver et al. 1990:50). The size of the curve increases as secondary calcium carbonate accumulates in the sample during burial and as fired clays weather and rehydroxylate to their initial state. Therefore, these curves only provide a minimum firing temperature. The standards to which they are compared were fired to 100°C increments from 500° to 900°C for 15 to 20 minutes and then they were run in the DTA. The extent of unreacted materials is measured by the size of the curve. The assumption was made that the composition of decomposing minerals and the burial conditions for all the samples tested was approximately the same. In reality, however, this was not always the case as certain parts of the sites lay considerably downslope the Pavlov Hills and closer to the river. If the amount of lime increased above that of the standard or if the burial conditions proved more acidic, a lower firing temperature would be reported. The hearth sample and 3 of the eight ceramic samples were fired to 800°C, as the endothermic curve is very small and virtually no unreacted material is present. The other 7 samples were fired to 600° or 700°C, because a small curve is present indicating some unreacted material is present.

2.3. Interpretations

Earthy material consisting of micaceous illitic clay, quartz and powdered limestone was used in a wetted state to form small, rounded lumps and figurines. Surfaces were smoothed, intentional shaping of the fragments took place, and pieces were preformed and added to one another. Some of the raw material was high in powdered limestone. Some of this material was not fired, and some was smudged or smoked in a fire to a temperature probably below about 600°C. No lime plaster microstructures were found which would indicate the presence of a lime plaster technology. In addition, the compositions were too high in clay to form strong or durable lime plasters. Some of the raw material was low in powdered limestone and high in clay, and was suitable for use as a fired ceramic. Of fourteen samples having an appropriate composition, 10 were fired to between 600° and 800°C and were found to be stable, durable and hard clay-based ceramics. Four were not. In addition, one sample from near a hearth was fired to about 800°C.

The variability of composition imposed limits on the ceramic technology practiced at Pavlov I. To test whether the earthy materials would have formed reasonable clay-based ceramics required empirical testing, as the raw materials had a similar appearance and texture. However, the presence of fired ceramics indicates that a successful technology was practiced at Pavlov. A firing temperature of 800°C was found in both a fragment of hearth and three ceramics fragments. A lower temperature of 600° to 700°C was found in seven other ceramic fragments. Thus, a range of firing temperatures is found in the ceramics which is consistent with firings using a bonfire, hearth or banked, walled kiln.

The evidence for thermal shock is negative among the 29 non-figurative pieces examined. Evidence for thermal shock, however, was found among the figurative pieces. We have previously presented an in depth argument why we interpreted some examples of fragmentation found in the Dolní Věstonice I assemblage as resulting from thermal shock (Vandiver et al. 1990). We augment that argument here by pointing out that the parts of several figurines from Dolní Věstonice I cannot be refitted together, even though the external shape is continuous and the internal faceted fracture surfaces mirror one another. In other cases cracks have opened in the pieces. These cracks and fracture surfaces at first appear to be the result of shrinkage. When tested, however, the ceramic body had 0 to 0.5% linear shrinkage because there were many coarse rock fragments, measuring 10 - 300 microns in maximum diameter and thus falling outside the range of clay-sized particles, which minimized shrinkage. The observed near-zero shrinkage discounts the shrinkage process as the cause of the lack of refit and cracking. The second possible main cause of such cracking is shrinkage in firing. The measured firing shrinkage, however, is also near zero. Our test results have shown that the observed pattern of fracture, cracking and warping can be produced by what would be considered "unceramic" practices (i.e. practices contrary to the production of a whole object) - namely, by placing unfired ceramic pieces with a gradient in water content into a thermal gradient in the fire. Doing so causes the ceramic to thermal shock or explode. We further noted that these ceramics were very porous - about 20%-40% vol. - a feature which would have made them dry evenly.

We have argued that to achieve such gradients in water content and temperature as we observed in the Dolní Věstonice I assemblage required intentional human intervention in what would be considered natural patterns of physical processes in the drying and firing of ceramics. Finally, observations under the scanning electron microscope of the fracture surfaces and the internal surfaces of cracks showed many thermal shocked, exploded grains, which reinforced our conclusions that thermal shock had occurred.

3. The Inventory

The Pavlov ceramics inventory, consisting of both fired and unfired pieces, is composed of small sized pieces the largest of which does not exceed 5.49 cm in length and 24 grams in weight.

Table 1. Clay Pieces from Pavlov I - 1952-1953 Excavations

N= 1,332 pieces

Unworked pieces:	N = 200	15% of inventory
- black	- N = 47 (23.5%)	
- gray	- N = 143 (71.5%)	
- yellow to tan	- N = 10 (5.0%)	
Worked:	N = 1,132	85% of inventory
- black	- N = 134 (11.8%)	
- gray	- N = 971 (85.9%)	
- yellow to tan	- N = 26 (2.3%)	

3.1. The Unworked Fragments

As Table 1 indicates, some 15% of the pieces consist of angular fragments which show no traces of workmanship. The pieces range in size from small (mean weight of 0.7 grams, N = 123), to medium (mean weight 3.5 gr., N = 68) to large (mean weight 5.8 gr., N=9) with small sized pieces predominating. These fragments shade from black to tan and the distribution of their colors is comparable to that found among the worked or shaped pieces.

3.2. The Worked Pieces

The majority of the pieces are worked and contain at least one side that bears traces of smoothing and shaping and often joints where the adding of one piece to another had occurred. These traces, like those observed in the Dolní Věstonice I assemblage , indicate that the pieces were worked in an additive fashion.

As shown above, morphological analyses indicate that their surfaces were worked and that bits of preformed clay body parts were added to one another. Optical microscopy showed that platelets of mica were aligned parallel to the curved ceramic surfaces, thus indicating forming into somewhat spherical lumps. In some cases, a thin layer of clay body measuring 3 to 4 mm. was smeared or pressed over the surface of a lump of clay, increasing its size from, for instance, 9 to 15 mm. However, these surface layers are not evenly applied, but are probably the result of rolling and pressing the lump and adding some material, then rolling and pressing the lump again. Xeroradiography confirms the presence of internal joints as well as occasional surface layers.

As at Dolní Věstonice I, there is little evidence that modeled pieces were smoothed with tools, wiped, or scraped. Convex surfaces were usually not reworked while many concave surfaces show traces of impression with other small implements which were used to incise details of bodies and faces.

Table 2. Worked Clay Objects

N = 1,132 pc.

Non-figurative	N = 1,101	97 % of worked pieces
- black	- N = 116 (10.5%)	
- gray	- N = 962 (87.4%)	
- yellow to tan	- N = 23 (2.1%)	
Figurative:	N = 31	3 % of worked pieces
- black	- N = 18 (58.1%)	
- gray	- N = 10 (32.3%)	
- yellow to tan	- N = 3 (9.6%)	

3.2.1. Non-figurative ceramics

Table 2 shows that the Pavlov I inventory, like that at Dolní Věstonice I, primarily consists of non-figurative objects which here make up 97% of the pieces with traces of shaping. The majority of these pieces are gray in color - this contrasts with the predominance of black pieces in the figurative inventory.

Table 3 presents the composition of the non-figurative Pavlov I assemblage and shows that, as at Dolní Věstonice I, the irregularly shaped small (4-10 mm) gray pellets constitute most of the non-figurative pieces.

Table 3. The non-figurative inventory

	N	mean weight	total weight
A. Pellets	948	0.6 gr.	610.60 gr.
- black	- N = 87 (9.0%)		
- gray	- N = 851 (90.0%)		
- yellow to tan	- N = 10 (1.0%)		
B. Flat fragments	123	1.76 gr.	214.35 gr.
- black	- N = 22 (18.0%)		
- gray	- N = 94 (76.0%)		
- yellow to tan	- N = 7 (6.0%)		
C. Slablike fragments with flat/convexo/concave profiles	30	3.6 gr.	107.67 gr.
- black	- N = 7 (23.0%)		
- gray	- N = 17 (57%)		
- yellow to tan	- N = 6 (20 %)		

The pellets show smoothing on more than two of their surfaces while the flat fragments primarily exhibit smoothing on just one surface. Some objects in both categories show evidence of being impressed with small-sized tools. A few bear impressions of partial fingerprints and/or palm prints.

Slablike fragments making up the third category of non-figurative worked objects feature slight bowing on one surface. Like the flat fragments they are crude and poorly worked, small in size and thin,ranging in thickness from 0.6-1.5 cm, with most measuring 1.0 cm or less. The slightly concave sides of the slablike fragments often bear predominantly linear impression which cover the entire interior surface of the fragments. The continuous nature of these impressions suggest that they resulted either from the wetted loess being smeared on the outside of some sort of larger sized objects and/or that larger sized objects were placed on wet loess. At least some of these impressions may be from small linear vegetal elements such as sticks, grasses, or pine needles. While the impressions on fragments excavated in the 1952-1953 field seasons were not distinct enough for identification, four of those excavated during the 1954 season bear distinct negative impressions of fabric (either textile or basketry, J. Adovasio, personal communication 1993).

The possible use of loess, which when wet would have been somewhat plastic, as a bonding agent has been previously suggested by Klíma (1955) who reported excavating a semi-circular windscreen adjacent to a hearth of dwelling #1 at Pavlov I that was made of mammoth bones held together by silty clay. Adovasio's identification of fabric impressions on the Pavlov I pieces suggests that wetted loess may have also been used as an outside coating on baskets or bags. These two observations strongly suggest a wider use of clay at Pavlov I that documented for Dolní Věstonice I, where we reported ceramic technology primarily used for the making and firing of animal and female figurines (Vandiver et al. 1990).

3.2.2. Figurative ceramics

The figurative pieces, because of their highly fragmented nature, were more difficult to classify into discrete unambiguous categories. Our prior research on the Dolní Věstonice I ceramics had shown that the Pavlov culture-bearers modeled figurative clay pieces by an additive process of sticking bits and pieces of the preformed wetted loess together. This observation held true for the Pavlov I inventory

Table 4. The Composition of the Figurative Pieces

Anthropomorphic	1	3 % of figurative pieces
- black	- N = 1 (100%)	
Zoomorphic	2	6 % of figurative pieces
- gray	-N = 2 (100%)	
Anthropomorphic or zoomorphic	28	91 % of figurative pieces
- black	- N = 17 (60.7%)	
- gray	- N = 8 (28.6%)	
- yellow to tan	- N = 3 (10.7%)	

as well, resulting in a figurative assemblage where, as Table 4 shows, the majority of the fragments (91%) consisted of body parts which could not be clearly classified as depicting anthropomorphic or zoomorphic mammalian taxa. It is important to note that a considerably greater percentage of these figurative pieces were gray or black in color, indicating that they were fired ceramics, than observed among the non-figurative inventory. This observation suggests that intentional firing in hearths or kilns was predominantly used in the production of figurative pieces while the ceramic technology used for non-figurative purposes was not as closely associated with pyrotechnology.

a. anthropomorphic or zoomorphic pieces

These pieces were small in size and quite fragmented. Since similar modeling techniques were used to fashion somewhat medio-laterally flattened small triangular clay cones used to model both ears and legs on the figurines, three pieces were classified as add-on ears and/or leg cones. Two of these were yellow to tan in color, one was black. None exhibited evidence of thermal shock.

The second category consisted of leg cones with or without feet. These ranged from fairly static, straight and massive in contour, accentuated by a certain degree of medio-lateral flattening, to slightly elongated bowed leg forms exhibiting a degree of dynamic stylization. All of these, like the remainder of the figurative category, exhibited degrees of stylization seen in the emphasis on the silhouette over natural three-dimensional contours and a simplification of detailing to essential diagnostic features at the expense of realism.

All of these 15 pieces exhibited diagonal crotch fractures or breaks, probably the result of thermal shocking of imperfectly dried or partially rewetted clay pieces upon firing. Thus, for example, 4 of the seven leg cones without modeled feet are black in color and show evidence of thermal shock fractures. The same holds true for 3 of the 5 black leg cones where the foot had been originally modeled but had subsequently broken off. Thermal shock type fractures were also observed on 2 gray leg cones initially fashioned without feet. The pieces with feet in some cases had modeled flat feet which presumably made the bodies they were originally attached to able to stand flat while in others the feet were just suggested by diagonal extensions that would not have encouraged a flat placement of the figurines on the ground. The fourth category consisted of 10 body-part fragments with 7 black and three gray in color. Five (71%) of these seven fragments bore signs of having been thermally shocked. The fragments were too small and indistinct for assignment to specific body parts. One fragment in the shape of a tear drop with one flattened side may have depicted a female breast.

b. zoomorphic fragments

Two large fragments could be identified to specific animal species. The first, a gray torso of a bear measured 2.86 cm in length, 1.64 cm in width, 0.90 cm in thickness, and weighed 24.0 grams (see chapter III for illustrations). This heavy and massive but symmetrical middle and rear portion of the body, vertically broken behind the neck, featured foreshortened legs which allowed the body to stand flat on the ground. The same minimalist stylization is repeated on the animal's posterior where the tail is just faintly suggested. The bear's torso contains four intentional holes produced by a sharp object being stuck into the wet clay body. Two large holes measuring some 0.40 cm in depth are located on the ventral side of the animal - one in the area of the right foot and the other between the forelegs. The animal's right flank contains two triangular holes measuring 9 x 2.5 x 4 mm in size and about 0.40 cm in depth. The second piece represents a stylized head of a rhinoceros measuring 5.26 cm in length, 2.67 cm in width, and 1.78 cm in thickness and weighing 13.5 grams. This head, gray in color, was originally fashioned as a head and not attached to a body. It is symmetrical in contour, accenting the cylindrical shape of the head, and shows a considerable degree of stylization which accents the silhouette of the head at the expense of such naturalistic details as horns and mouth. The animal's eyes are indicated by small punched in holes. The neck section wedges off into a slightly flaring triangular contour evocative of the occipital crests found on the napes of rhinoceros necks and was produces by squeezing wet clay between fingers.

c. the anthropomorphic fragment

The sole anthropomorphic figurine fragment in the inventory is a very small black rectangular leg with foot that measures 1.90 cm in length, 0.69 cm in width, 0.47 cm in thickness, and weight 0.7 grams. The piece has a tall and slender contour which features slight elongation. The anterior-posterior flattening evident in the piece which gives it a somewhat square silhouette was produced after the figurine was fashioned but before it was fired. The top of the leg has a horizontal crotch break indicating that the fragment was joined to a body and probably broke away from it during firing. The bottom part features a suggestion of a foot - but its somewhat diagonal form indicates that the figurine could not "stand" flat on the ground.

4. Some General Conclusions

In this study we report on our analyses of just a small segment of the ceramic objects recovered at Pavlov I. Because we deal with only those materials recovered during the 1952-1953 excavations, the ensuing conclusions are tentative and preliminary in nature. While in need of future corroboration, they do indicate some interesting differences compared to materials from Dolní Věstonice I. These differences, however, occur against a background of considerable continuity.

The technological analysis of the Pavlov I ceramic inventory indicates that a much higher proportion of these pieces were unfired when compared to the samples examined from Dolní Věstonice I. Since local loess was used at both sites to make the ceramic objects, part of the explanation for this difference can be found in the composition of the loess itself - namely, the Pavlov loess was much less suitable to the firing of ceramics.

The presence of large numbers of pellets at both sites, many of which at Pavlov I were not fired, remains enigmatic, but suggests the use of clay for purposes other than the fashioning and firing of figurines. The unfired and low fired slablike flat pieces with impressions on their slightly concave sides strengthens this suggestion and argues for wider use of clay than observed at Dolní Věstonice I. The considerably higher ratio of unfired pieces in the Pavlov I non-figurative inventory, together with Klíma's (1955) observation of the use of clay in the construction of a bone fire screen, tentatively indicate that ceramic pyrotechnology may have been used just for the production of figurines while unfired clay had a wide utilitarian use.

The figurative pieces at Pavlov I show that a much higher percentage were fired than do the non-figurative ones. In addition, it is these fired fragments which exhibit evidence of thermal shock fractures. These data are in good accord with those from Dolní Věstonice I where we reported intentional thermal shocking of the animal and female figurines during the firing process (Vandiver et al. 1990). Since, as we reported previously, thermal shocking of figurines made of local loess would have required considerable extra effort, and given that the overwhelming majority of the figurines at both sites are fragmented, we suggest that intentional thermal shocking may have been practiced at Pavlov I as well.

Although the figurative ceramic inventory excavated at Pavlov I in the 1952 and 1953 field seasons is fragmented and small, it exhibits certain features characteristic for the Pavlov culture. These include the small size of the figurines, their aggregate nature, and stylization which accents the most evocative body parts of the depicted animals. Detailing is minimal and accomplished by a few deftly placed indentations made by small tools and fingernails. In some cases, as with the rhinoceros head or with footless leg fragments, only parts of the body were modeled and fired. The distortions observed on some body fragments suggest that the pieces were thrown down while still wet, while the intentional punctures observed on the body of the bear recovered during the 1953 field season suggest additional manipulation of the figurines prior to firing.

Finally, some possible differences can also be observed in the spatial distribution of the ceramic fragments at Pavlov I and Dolní Věstonice I. While at both sites this inventory is strongly associated with hearths and kilns, at Dolní Věstonice I the kilns with the majority of the fragments are somewhat separated spatially from the residential part of the site. At Pavlov I, on the other hand, data from some 290 m² excavated in 1952-1953, which uncovered residential features together with hearths and ceramic fragments, suggest a more widespread use of ceramic technology by the residents of the site. Given the limited size of the area excavated, this interpretation necessarily remains a tentative one and one in need of corroboration with evidence from other parts of the site.

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Tab.5. Results of testing loess and ceramic samples from Pavlov

Number	Color	Hardness	Durability	Acid Test	Elemental Composition	Fired in °C or Unfired
RED, BROWN, GREY OR BLACK COLOR OR MOTTLED, AT FIRST SEEMING TO BE FIRED						
1	Brown	Medium	+	Fizzed	Si, Al, Ca, Fe, K: Mg, Ti	800
2	Red	Hard	+	Fe Residue	Si, Al, Ca, Fe, K: Mg, Ti, Na	800
3	Yellow-Brown	Soft	-			
	Brown Mottled	Medium	+		Si, Al, Ca, Fe, K: Mg, Ti	UF
4	Yellow-Brown	Soft	-	Fizzed	Si, Ca, Al, K, Fe: Mg, Ti	UF
5	Red	Hard	+	Fe Residue	Si, Al, Ca, Fe, K: Mg, Ti	800
6	Grey Interior	Medium	+	Fe Residue	Si, Al, Fe, K, Ca: Ti, Mg, P	6-700
	Brown Exterior	Medium	+			
7	Yellow-Brown	Soft	+	Fe Residue	Si, Al, Ca, Fe, K: Mg, Ti	600
8	White, Yellow, Coarse	Soft	+		Si, Al, K, Fe, Ca: Ti, Mg	UF
9	Bright Yellow-Orange, Probably a Pigment	Hard	+	Fe Residue	Fe, S, Si: K, Al, Ca, Na, P	UF
10	Yellow-Brown	Soft	+	Fizzed	Si, Al, Ca, Fe, K: Ti, Mg, Na	600
11	Brown	Medium	+	Fizzed	Si, Al, Ca, Fe, K: Mg, Ti	6-700
12	Brown	Soft	-	Fizzed	Si, Al, Fe, Ca, K: Mg, Ti, Na	UF
13	Grey Interior Mottled Black & Yellow Exterior	Hard	+		Si, Al, Fe, K, Ca: Mg, Ti, P	6-700
14	Grey	Soft	+		Si, Al, Ca, Fe, K: Ti, Mg	6-700
YELLOW APPEARANCE, SEEMING AT FIRST TO BE UNFIRED						
15	Yellow	Soft	-	Fizzed	Si, Al, Ca, Fe, K: Ti, Mg, Na	UF
16	Yellow & White Mottled	Soft	-	Fizzed	Si, Al, Ca, Fe, K: Mg, Ti, Na	UF
	Shell	Medium	+	Fizzed	Ca: Si, Al, Fe	UF
17	Yellow & White Mottled	Soft	-	Fizzed	Si, Al, Ca, Fe, K: Mg, Ti, Na, P	UF
18	Yellow	Soft	-	Fizzed	Si, Al, Ca, Fe, K: Ti, Mg	UF
19	Yellow	Soft	-	Fizzed	Si, Ca, Al, Fe, K: Mg, Ti, Na, P	UF
20	Yellow	Soft	-	Fizzed	Si, Ca, Al, K, Fe: Mg, Ti	UF
21	Yellow	Soft	-	Fizzed	Si, Ca, Al, Fe, K: Mg, P	UF
	and White	Medium	+	Fizzed	Ca, Si, Al, Fe, K: Mg, Ti, Na, P	UF
22	Yellow & White	Soft	-	Fizzed	Si, Al, Ca, K, Fe: Mg, Ti, Na	UF
23	Yellow & White	Soft	-	Fizzed	Si, Al, Ca, K, Fe: Mg, Ti, Na	UF
24	Yellow & White	Soft	-	Fizzed	Si, Al, K=Fe: Mg, Ti, Mn	UF
25	Yellow & White	Soft	-	Fizzed	Si, Al, Ca, K, Fe: Mg, Ti, Na	UF
26	Yellow	Soft	-	Fizzed	Si, Al, Ca, K, Fe: Mg, Ti	UF
27	Yellow-Light Brown	Hard	+	Fe Residue	Si, Al, Ca, Fe, K: Mg, Ti, P	6-700
28	Yellow-Light Brown	Soft	-	Fizzed & Fe Residue	Si, Al=Ca, Fe, K: Mg, Ti	UF
29	Yellow-Brown	Soft	-	Fizzed & Fe Residue	Ca, Si, Fe, Al, Mg, S, K: Ti, Na	UF
30	Tooth, Orange & Brown	Medium	+	Fizzed & Fe Residue	Ca, P: Fe, Si, Al, Mg	UF
EXCAVATED LOESS STANDARDS, BELIEVEDTO HAVE BEEN UNFIRED						
A	Yellow	Soft	-	Fizzed	Si, Al, Ca, Fe, K: Mg, Ti, S	UF
B	Yellow Powder	Soft	-	Fizzed	Si, Al, Fe, Ca, K: Mg, Ti, Na	UF
	Yellow Lump	Soft	-	Fizzed	Si, Al, Fe, Ca, K: Mg, Ti, Na	UF
C	Yellow	Soft	-	Fizzed	Si, Al, Ca, Fe, K: Mg, Ti, Na	UF
D	Orange & Some Grey-Brown Sample from Hearth	Medium	+	Fizzed & Fe Residue	Si, Al, Fe, Ca, K: Mg, Ti, Na	800

Notes to table 5: The Samples were classified using an optical microscope in order to determine whether they appeared fired or unfired. Then the tests were carried out to add further evidence to the initial characterization. The initial classification was incorrect where compositional mixing rather than firing variability occurred, and where unexpected compositions were found.

X-ray diffraction was carried out on samples 1, 2, 3, 4, 5, 15, and A, B, C and D. The results show quartz, calcite, illite, mica, and minor felsdpar as calcian albite (JCPDS 41-1486) and anorthite (JCPDS 41-1486). Mohs hardness was measured as soft (1½-2), medium (2-3) and hard (2-3¹/3). Acid test included 2N solution of HCl; "Fizzed" means sample gave off CO2, and iron-containing residue is indicated by "Fe Residue". Samples were boiled to determine durability; "+" indicates sample was durable, and "-" indicates sample dissolved. Elemental composition was taken by energy dispersive x-ray attachment on JEOL 840-II scanning electron microscope by counting for 180 seconds at 200x. Limit of detection is 0.5%, and no elements lighter than Na can be detected with this system (Tracor-Northern). Peaks appear in descending order of peak intensity. The ":" is placed to separate peaks which are less than 10% of the maximum peak intensity. The firing temperature was judged by comparison with samples of loess fired to known 100 °C increments of temperature, using a differential thermal analyzer (Perkin-Elmer DTA-1700).