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## Chemical Characterization of Local Anatolian and Uruk Style Sealing Clays from Hacinebi

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## Abstract

To test the hypothesis of an Uruk enclave existing side by side with the local Anatolian inhabitants of Hacinebi and the possibility of parallel administrative systems at the site, chemical characterization, by instrumental neutron activation analysis (INAA), was used to classify the two styles of ceramics and sealing clays. The results of this research clearly show that the clays employed in the sealing containers bearing local Anatolian stamp sealings can be shown to be local to Hacinebi. The clay artifacts bearing the impressions of Uruk style cylinder seals can be readily distinguished from the local sealings. Moreover, some of the Uruk style artifact groups can be inferred to be made from locally available clays, supporting the hypothesis of parallel Anatolian and Uruk administrative systems at the site. The remaining Uruk artifacts appear to be foreign to the Hacinebi area and have their closest matches with sealings from Susa and other sites in Khuzistan. These results imply that not only were people using Uruk style administrative artifacts resident at Hacinebi, but that active, two way communication was maintained with the Uruk heartland to the south.

## Résumé

Pour tester l'hypothèse d'une enclave urukéenne co-existant avec une population locale anatolienne à Hacinebi ainsi que l'existence possible de systèmes administratifs parallèles sur le site, nous avons fait appel à la caractérisation chimique des argiles, en utilisant l'activation neutronique (INAA); celle-ci a permis de classer les argiles des deux styles de céramiques et de scellements. Les résultats de cette recherche montrent clairement que les argiles employées pour les jarres scellées dont les scellements portent des impressions de style anatolien local ont une origine locale et proviennent de Hacinebi. Les objets en argile portant des impressions de cylindres-sceaux de style urukéen peuvent être, sans difficulté, distingués des scellements locaux. On peut aussi suggérer que quelques groupes d'objets de style urukéen étaient faits à base d'argile locale, ce qui étayerait l'hypothèse de l'existence sur le site de systèmes administratifs parallèles anatolien et urukéen. Les autres objets urukéens paraissent allochtones et trouvent leurs meilleurs parallèles dans des scellements de Suse et d'autres sites du Khuzistan. Ces résultats montrent donc que non seulement des personnes utilisant des objets de caractère administratif urukéen résidaient à Hacinebi mais que des communications, actives dans les deux sens, se maintenaient avec le foyer urukéen du Sud.

# CHEMICAL CHARACTERIZATION OF LOCAL ANATOLIAN AND URUK STYLE SEALING CLAYS FROM HACINEBI

M.J. BLACKMAN

**Abstract :** *To test the hypothesis of an Uruk enclave existing side by side with the local Anatolian inhabitants of Hacinebi and the possibility of parallel administrative systems at the site, chemical characterization, by instrumental neutron activation analysis (INAA), was used to classify the two styles of ceramics and sealing clays. The results of this research clearly show that the clays employed in the sealing containers bearing local Anatolian stamp sealings can be shown to be local to Hacinebi. The clay artifacts bearing the impressions of Uruk style cylinder seals can be readily distinguished from the local sealings. Moreover, some of the Uruk style artifact groups can be inferred to be made from locally available clays, supporting the hypothesis of parallel Anatolian and Uruk administrative systems at the site. The remaining Uruk artifacts appear to be foreign to the Hacinebi area and have their closest matches with sealings from Susa and other sites in Khuzistan. These results imply that not only were people using Uruk style administrative artifacts resident at Hacinebi, but that active, two way communication was maintained with the Uruk heartland to the south.*

**Résumé :** *Pour tester l'hypothèse d'une enclave urukéenne co-existant avec une population locale anatolienne à Hacinebi ainsi que l'existence possible de systèmes administratifs parallèles sur le site, nous avons fait appel à la caractérisation chimique des argiles, en utilisant l'activation neutronique (INAA); celle-ci a permis de classer les argiles des deux styles de céramiques et de scellements. Les résultats de cette recherche montrent clairement que les argiles employées pour les jarres scellées dont les scellements portent des impressions de style anatolien local ont une origine locale et proviennent de Hacinebi. Les objets en argile portant des impressions de cylindres-sceaux de style urukéen peuvent être, sans difficulté, distingués des scellements locaux. On peut aussi suggérer que quelques groupes d'objets de style urukéen étaient faits à base d'argile locale, ce qui étayerait l'hypothèse de l'existence sur le site de systèmes administratifs parallèles anatolien et urukéen. Les autres objets urukéens paraissent allochtones et trouvent leurs meilleurs parallèles dans des scellements de Suse et d'autres sites du Khuzistan. Ces résultats montrent donc que non seulement des personnes utilisant des objets de caractère administratif urukéen résidaient à Hacinebi mais que des communications, actives dans les deux sens, se maintenaient avec le foyer urukéen du Sud.*

**Key-words :** *Chemical characterization, Clay, Cluster analysis, Instrumental Neutron Activation Analysis (INAA), Sealings, Administration, Exchange, Hacinebi, Uruk expansion.*

**Mots clefs :** *Caractérisation chimique, Cluster analysis, Analyse par activation neutronique, Scellements, Administration, Echanges, Hacinebi, Expansion urukéenne.*

## INTRODUCTION : INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS (INAA) OF CLAY SEALINGS AND THE INVESTIGATION OF PREHISTORIC ADMINISTRATIVE ORGANIZATION

Attempts to examine the nature of systems of administration and regulation operating at early state level sites in the Middle East invariably turn to those artifacts most closely associated with those activities : seal impressed clay objects and the seals themselves. The seal impressed clay objects carry multiple lines of information that bear on the administrative system in which they functioned. These lines have traditionally included the function of the sealed object (bulla, tablet, closure), the type of the container being sealed, the distribution of the sealings at the site, and the iconography of the seals. Accounting devices such as bulla or tablets are portable and may have moved with shipments of sealed goods between sites or have recorded strictly local storage and disbursement activities. The type of container that was sealed carries information on the portability of the sealed goods. Jar and bale tag sealings may have moved great distances, while door lock sealings obviously have not. The distribution of sealings at the site also bear on the nature of the accounting system. Concentrations in storage contexts imply a local accounting system, while scatters throughout the site may imply movement of sealed goods into the site from the outside. The iconography of the seals allows parallels to be drawn on a local or regional basis. While each of these separate lines of information can be used to imply local accounting system or a regional or long-distance exchange network, they cannot demonstrate the actual movement of sealed goods between sites.

In recent years, chemical characterization of the sealing clays has been used to provide an independent new line of evidence to demonstrate the local or non-local origin of sealed objects through the chemical analysis of the sealing clays and comparison with other unfired clay and ceramics of undisputed local origin. Purely local accounting systems have been documented for Uruk period sealings at Arslantepe<sup>1</sup> and Banesh period sealings at Tal-e Malyan<sup>2</sup> and the presence of the importation of sealed goods has been documented at Tal-e Malyan<sup>3</sup>, Tepe Gawra<sup>4</sup>, Tel Leilan<sup>5</sup>, and at sites on the Deh

Luran Plain<sup>6</sup>. This new tool, chemical characterization, is now applied to help in the understanding of the Uruk period administrative system(s) in operation at the site of Hacinebi in the Euphrates river valley of southeast Turkey.

## HACINEBİ SEALINGS

Excavations at Hacinebi in mid to late fourth millennium BC deposits dating to phase B2 have uncovered stratigraphically contemporaneous deposits with culturally distinct artifact assemblages. In some deposits and parts of the site, all ceramics are of Local Anatolian Late Chalcolithic style, while other contemporaneous deposits and areas contain predominantly or exclusively Uruk Mesopotamian style ceramics. Administrative artifacts recovered from these two types of deposits also mirrored the ceramics. Clay sealings impressed with stamp seals bearing local Anatolian motifs were associated with the deposits containing local Anatolian ceramics, and clay sealings impressed with cylinder seals rendered in Uruk motifs were associated with the deposits containing Uruk style ceramics. Administrative artifacts recovered in these two areas also mirrored the ceramics<sup>7</sup>. Of particular interest was the recovery of two artifacts closely associated with Uruk administrative activities in the Uruk heartland to the south : an unopened hollow clay ball bearing the impressions of two Uruk style cylinder seals and a tablet sealed with an Uruk style cylinder seal<sup>8</sup>.

The presence of the ceramics and administrative artifacts has led to the hypothesis of an Uruk enclave existing side by side with the local Anatolian inhabitants of Hacinebi and to the possibility of parallel administrative systems at the site<sup>9</sup>. To test this hypothesis, chemical characterization, using instrumental neutron activation analysis (INAA) was used to classify the two styles of ceramics and sealing clays. This paper presents the results of the analysis of the sealing clays.

The sealing clay data set consisted of 73 unfired clay artifacts : 29 were sealings bearing the impression of local Anatolian stamp seals; 9 were sealings bearing Uruk style cylinder seal impressions; and 3 were samples of clay objects presumed to be made of local Hacinebi clays (a hearth fragment, an andiron, and a clay object from Hellenistic contexts at the site). The remaining 32 samples were from

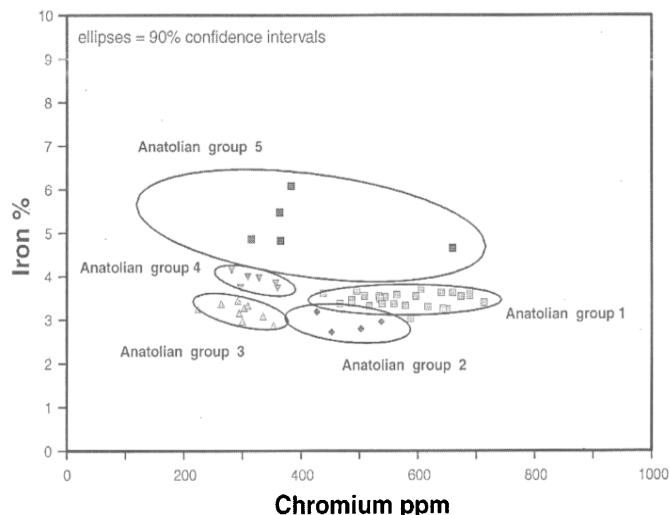
1. BLACKMAN, n.d. (b).  
2. ZEDER and BLACKMAN, n.d. (c).  
3. BLACKMAN, 1985.  
4. ROTHMAN and BLACKMAN, 1992.  
5. BLACKMAN, n.d. (a).

6. BLACKMAN, 1985.  
7. STEIN, BERNBECK *et al.*, 1996.  
8. PITTMAN, 1996.  
9. STEIN, 1998.

**Table 1 : Summary of INAA Experimental Parameters.**

Element	Nuclide	Gamma Ray Energy (Kev)	Conc. In Standard SRM 1633	Count <sup>1</sup>	Analytical Precision SRM 679
Na	Na-24	1369	0.32%	1	2.2%
K	K-42	1525	1.61%	1	5.3%
Ca	Ca-47	1297	4.70%	1	n.d.
Sc	Sc-46	889	27.0 ppm	2	1.8%
Cr	Cr-51	320	131. ppm	2	3.0%
Fe	Fe-58	1099 & 1292	6.20%	2	3.0%
Co	Co-60	1173 & 1333	41.5 ppm	2	2.0%
Zn	Zn-65	1115	213. ppm	2	10.4%
As	As-76	559	61.0 ppm	1	5.6%
Rb	Rb-86	1077	125. ppm	2	6.8%
Sr	Sr-85	514	1700. ppm	2	n.d.
Sb	Sb-122	564	6.9 ppm	1	17.5%
Cs	Cs-134	796	8.6 ppm	2	2.8%
Ba	Ba-131	496	2700. ppm	1	12.1%
La	La-140	1596	82.0 ppm	1	1.7%
Ce	Ce-141	145	146. ppm	2	2.3%
Sm	Sm-153	103	12.9 ppm	1	2.5%
Eu	Eu-152	1408	2.5 ppm	2	3.2%
Tb	Tb-160	879	1.9 ppm	2	13.9%
Yb	Yb-175	396	6.4 ppm	1	5.1%
Lu	Lu-177	208	1.0 ppm	1	6.9%
Hf	Hf-181	482	7.9 ppm	2	3.7%
Ta	Ta-182	1221	1.8 ppm	2	6.8%
Th	Pa-233	312	24.8 ppm	2	2.5%
U	Np-239	106	11.6 ppm	1	15.3%

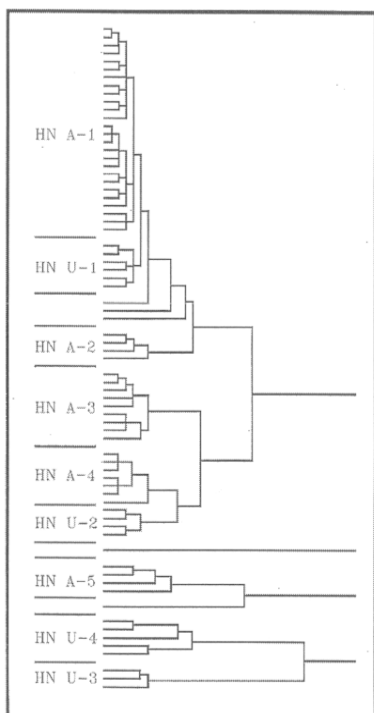
n.d. not determined  
<sup>1</sup> count 1 : 1 hour after a 6/day decay ; count 2 : 2 hours after a 30/day decay.



**Fig. 2 :** Plot of Iron vs. Chromium for the local Anatolian chemical groups.

sealings that either bore no seal impression or an impression that was too badly damaged to identify. Analysis was carried out using Instrumental Neutron Activation Analysis (INAA) at the Smithsonian Center for Materials Research and Education’s INAA laboratory at the National Institute of Stand-

ards and Technology (NIST) Nuclear Methods Research Facility in Gaithersburg, Maryland. Table 1 shows the 25 elements that are routinely quantified in the analysis of clays and ceramics at the Smithsonian.



**Fig. 1 :** Cluster analysis dendrogram for Hacinebi clay artifacts based on the elements : Na, K, Ca, Sc, Cr, Fe, Co, Rb, Cs, La, Ce, Sm, Eu, Yb, Lu, Hf, Ta, Th.

**ANALYTICAL METHODOLOGY AND RESULTS**

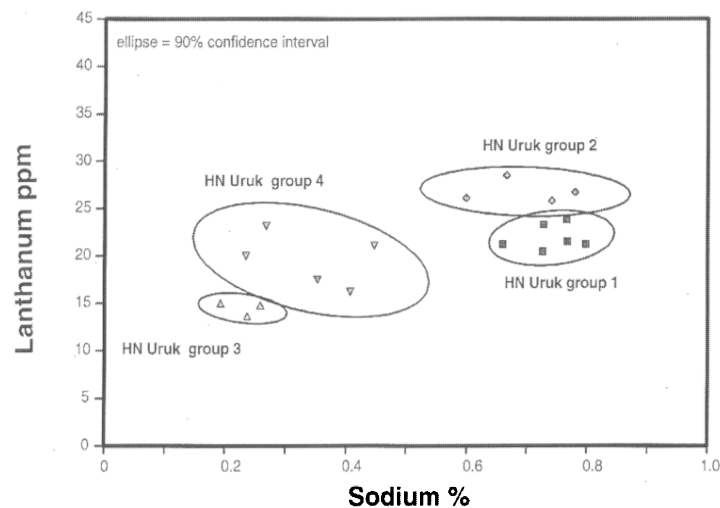
The data from the 73 clay artifacts was first processed by cluster analysis using a nearest neighbor clustering algorithm on a squared mean Euclidian distance matrix<sup>10</sup> generated using eighteen of the most precisely analyzed elements. Figure 1 shows the results of the cluster analysis separating of the Hacinebi clays into nine chemical groups with only five samples unassigned. The chemical groups designated HN A-1 through 5 contain all the local Anatolian sealings, while chemical groups designated HN U-1 through 4 contain all but one of the Uruk style artifacts. Binary elemental plots can be used to demonstrate the separation of the various chemical groups. The plot of Iron versus Chromium (fig. 2) shows that each of the local Anatolian groups are distinctive at the 90 % confidence level (i.e. the interval within which 90 % of the individuals within a discrete population will fall). Likewise, the plot of Lanthanum versus Sodium (fig. 3) shows the separation of the four Uruk style groups again at the 90 % confidence level.

10. SNEATH and SOKAL, 1973.

**Table 2 :** Mahalanobis Distance Calculations of the Probabilities of Samples Belonging to Hacinebi Anatolian group 1.

Reference group : Hacinebi Anatolian clay group 1 (N = 26)  
 Variables used : Na, K, Ca, Sc, Cr, Fe, Rb, Cs, La, Eu, Yb, Hf, and Th

Samples	Probabilities	Samples	Probabilities
Hacinebi Anatolian group 2		Hacinebi Uruk group 1	
HNB134	0.061	HN5179	0.378
HN3889	1.383	HN5460	2.538
HN3908	0.884	HBP064	0.936
HN3912	6.354	HNB230	0.046
Hacinebi Anatolian group 3		HN6294	0.001
HBP052	0.007	HNB227	0.021
HBP062	0.004	Hacinebi Uruk group 2	
HNB100	0.011	HN5298	0.278
HNB205	0.011	HN5828	0.202
HNB218	0.002	HNB135	0.470
HNB229	0.058	HNB231	0.006
HN3836	0.003	Hacinebi Uruk group 3	
HN3877	0.001	HNB136	0.000
HN8831	0.001	HNB137	0.000
Hacinebi Anatolian group 4		HNB215	0.000
HBP055	0.001	Hacinebi Uruk group 4	
HNB213	0.000	HBP068	0.008
HNB228	0.000	HNB105	0.001
HN3859	0.000	HNB223	0.001
HN3900	0.000	HN5835	0.246
HN5967	0.000	HN5839	0.000
Hacinebi Anatolian group 5		Un-grouped samples	
HBP060	0.000	HBP066	2.867
HNB201	0.000	HNB217	0.000
HN5811	0.000	HNB226	0.071
HN5971	0.000	HN3807	0.000
HN6379	0.000	HN3886	0.000

**Fig. 3 :** Plot of Lanthanum vs. Sodium for the Uruk style chemical groups.

Further tests of the statistical validity of the chemical groups were carried out using Mahalanobis Distance calculations and Hotelling's  $T^2$  statistic<sup>11</sup>. The only group containing enough samples to conduct this test was Anatolian

group 1. The test requires at least twice the number of samples as variables (elements) used. At least 12 elements are necessary to reduce the possibility of false inclusion in the test group. False exclusion is not a problem. Table 2 shows the probabilities that the samples assigned to the other chemical groups from Hacinebi could have been drawn from the che-

11. SNEATH and SOKAL, 1973.

**Table 3 :** *Distribution of Anatolian Stamp Seal Motifs among the Chemical Groups.*

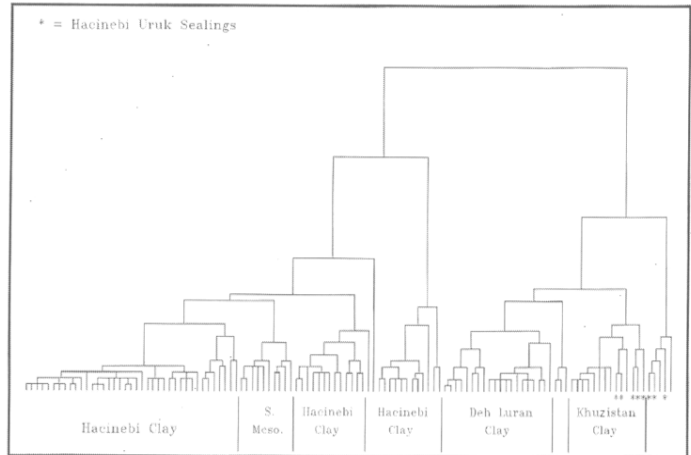
Chem. Group	Motif 1	Motif 2	Motif 3	Motif 4	Motif 5	Motif 6	Motif X-1	Motif X-2
HNA-1	present	present		present	present		present	
HNA-2				present		present		
HNA-3			present					
HNA-4		present	present				present	
HNA-5								present

mical population represented by Anatolian group 1. Almost all other samples are rejected from membership in HN A-1 at the 99 + percent confidence level. Note that in both the cluster analysis and in the elemental plots Anatolian group 2 and Uruk style group 1 are closely associated with Anatolian group 1; however, in Table 2 one can see only slightly elevated probabilities of any of the members of these two chemical groups belonging to Anatolian group 1. This strongly suggests that given a sufficiently large sample each of the other groups would be readily distinguishable from each other.

## DISCUSSION : LOCAL ANATOLIAN, SOUTH MESOPOTAMIAN, AND SOUTHWESTERN IRANIAN CLAY SOURCES

What then is the significance of these nine chemical compositional groups? The distribution of the Anatolian stamp seals among the five Anatolian groups (Table 3), shows that of the eight identified motifs, five are represented in the largest chemical group HN A-1. Anatolian groups 1, 2, 3 and 4 each share a motif with at least one other chemical group; only group HN A-5 does not share a motif with another Anatolian group. This strongly suggests that Anatolian groups 1 through 4 are made of clays locally available in the vicinity of Hacinebi. The local nature of these groups is supported by the presence of the andiron sample in Anatolian group 3 and the hearth fragment in Anatolian group 4. Anatolian group 5 may also be local, however, its dissimilarity from the other four Anatolian groups as shown in the dendrogram (fig. 1) and its lack of a shared seal motif with the other groups may indicate a more regional source for this group's clays.

The Uruk style artifacts present a more complex picture. Uruk style chemical groups 1 and 2 are closely related chemically, and as seen in the cluster analysis (fig. 1) both are related to Anatolian groups 1 through 4. Uruk group 2 also contains an unfired clay object recovered from the Hellenistic levels at Hacinebi. These factors would seem to suggest a local origin for the clays of these two Uruk style groups.



**Fig. 4 :** *Cluster analysis dendrogram comparing Hacinebi clay artifacts with sealing clays from southern Mesopotamia, Deh Luran, and Khuzistan.*

Further the sealed bulla with Uruk style sealings is firmly associated with Anatolian group 3. Taken together, these factors strongly indicate the presence of the full complement of Uruk administrative artifacts made from local Hacinebi clays.

The remaining two Uruk style groups, 3 and 4, are chemically dissimilar from the local Anatolian groups and from Uruk style groups 1 and 2 as shown in cluster analysis (fig. 1) and in elemental plots (fig. 3). To test the possibility that these two chemical groups could have come from the south, all of the Hacinebi clay artifacts were clustered with sealing clays from the Uruk area (Sakheri Sughir), the Deh Luran Plain (Farukhabad), and Khuzistan (Susa, Sharafabad, KS54)<sup>12</sup>. The Hacinebi clays of all the Anatolian chemical groups are readily distinguishable from the southern sources as shown in figure 4. The southern Mesopotamian clays, the Deh Luran clays, and the Khuzistan clays each form their own separate clusters. The clays of Hacinebi Uruk style groups 3 and 4, however, are closely clustered with sealing clays from Susa in Khuzistan.

It should be noted that in chemical characterization studies it is always easier to demonstrate that an artifact is not a

12. BLACKMAN, 1985.

**Table 4 :** Proposed geographic source for sealing clay groups.

<u>Chemical Group</u>	<u>Reason</u>
<u>Clays local to Hacinebi</u>	
HNA-1	Largest group, most likely represents local clays
HNA-2	Chemical Composition close to HNA-1
HNA-3	Andiron in this group
HNA-4	Hearth fragment in this group
HNU-1	Chemical Composition close to HNA-1
HNU-2	Chemical Composition close to HNU-4, unfired clay from Hellenistic levels in this group
<u>Clays local to Hacinebi or to the Region</u>	
HNA-5	Chemically dis-similar to « local » groups ; contains local Anatolian stamp sealings, but seal motifs are not found in other « local » chemical groups
<u>Imports from south</u>	
HNU-3	Matches one Khuzistan sealing from Susa
HNU-4	Matches several Khuzistan sealings from Susa

member of a specific group than it is to definitively prove that it is a member of that group. With this *caveat*, the data indicate that the clays used to make Hacinebi Uruk style groups 3 and 4 artifacts are much more similar to Khuzistan clays than they are to Hacinebi clays.

## CONCLUSIONS

Table 4 summarizes the results of this study. Six of the nine chemical compositional groups identified in the Hacinebi clay artifacts appear to be made of locally available clays. These include groups that contain nearly all of the local Anatolian stamp seal impressed artifacts and several of the Uruk style cylinder seal impressed artifacts including the bulla. One chemical group A-5, containing only local Ana-

tolian style sealings, could have a more regional origin and represent movement of sealed goods into Hacinebi from another site in the general area. Two groups of Uruk style sealings, including a cylinder seal impressed tablet, appear to be made of clays foreign to the Hacinebi area and possibly linked to Uruk sealings from Susa.

The chemical characterization study of the administrative artifacts from Hacinebi supports the hypothesis that parallel local Anatolian and Uruk administrative system were operating simultaneously at Hacinebi. While at the same time the Uruk enclave may have been maintaining close contact with the heartland to the south.

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