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TILMEN HÖYÜK: A MINERALOGICAL-GEOCHEMICAL CHARACTERIZATION OF SOME MBA AND LBA POTTERY SAMPLES

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1. INTRODUCTION

This is a report on the archaeometric studies we carried out on Simple Ware (hereafter SW), Kitchen Ware (KW), and Preservation Ware (PW) samples from the excavations at Tilmen Höyük.[1] Our aim is, on the one hand, to define the composition of these three functional ceramic classes and the manufacturing techniques employed (probable firing temperature and treatments of the raw material for dating purposes), on the other hand, to ascertain whether the pottery was locally manufactured by comparing it with the mudbricks found at the site, which were surely made of local raw material.

Here we present a representative sample of the assemblages dating from the Middle Bronze (hereafter MB) and from the Late Bronze (LB) ages, collected during the excavations. In particular, we analyzed samples throughout the whole 2nd millennium BC sequence of the site (cf. Marchetti 2008a; 2008b; 2008c; 2010). The transition from the Early Bronze to the beginning of the MBA (i.e. MB IA) is represented by samples from areas K5 and V, the MB IB period by samples from areas E, G and K5, MB IIB by samples from areas K5 and G (excavators deem the MB II assemblage from Area Q to be slightly earlier than the other two), and LB IA by samples from areas G, K5, M and Q.

2. MATERIALS AND ANALYTICAL TECHNIQUES

2.1 Materials

We tested 42 samples of Simple Ware, 10 of Kitchen Ware, and 12 of Preservation Ware, as well as 12 samples of mudbricks, found in the same areas where the pottery specimens were collected. Table 1a lists the pottery samples, classified with the initial TIL and a progressive number, assigned independently from the functional class and the

1 We would like to thank the scientific staff of Gaziantep Museum and that of the General Directorate for Cultural Heritage and Museums in Ankara, for the possibility of analyzing the samples at the University of Bologna. A. Bonomo helped us in preparing the samples for analysis.

actual sherd number; Table 1b lists instead the mudbrick samples with the initial MATIL. Tables also supply the number, class, locus, and date of each sample.

Sample	Sherd number	Class	Locus	Dating	Sample	Sherd number	Class	Locus	Dating
TIL 1	TH.06.G.80/9	SW	F.1282	MB IIB	TIL 34	TH.06.K5.196/10	PW	F.1417	MB IIB
TIL 2	TH.06.G.80/14	SW	F.1282	MB IIB	TIL 35	TH.06.K5.163/1	SW	F.1368	LB IA
TIL 3	TH.06.G.80/3	SW	F.1282	MB IIB	TIL 36	TH.06.K5.163/4	SW	F.1368	LB IA
TIL 4	TH.06.G.80/11	SW	F.1282	MB IIB	TIL 37	TH.06.K5.163/3	SW	F.1368	LB IA
TIL 5	TH.06.G.80/15	SW	F.1282	MB IIB	TIL 38	TH.06.K5.163/2	SW	F.1368	LB IA
TIL 6	TH.06.G.80/2	PW	F.1282	MB IIB	TIL 39	TH.06.K5.163/7	SW	F.1368	LB IA
TIL 7	TH.06.G.76/1	PW	F.1279	MB IIB	TIL 40	TH.06.K5.163/8	SW	F.1368	LB IA
TIL 8	TH.06.G.76/6	PW	F.1279	MB IIB	TIL 41	TH.06.K5.163/5	SW	F.1368	LB IA
TIL 9	TH.06.G.85/1	SW	F.1279	MB IIB	TIL 42	TH.06.K5.163/13	PW	F.1368	LB IA
TIL 10	TH.06.G.85/2	SW	F.1279	MB IIB	TIL 43	TH.06.K5.134/4	SW	F.1493	MB IB
TIL 11	TH.06.G.85/3	SW	F.1279	MB IIB	TIL 44	TH.06.K5.134/1	SW	F.1493	MB IB
TIL 12	TH.06.G.85/4	SW	F.1279	MB IIB	TIL 45	TH.06.K5.134/5	SW	F.1493	MB IB
TIL 13	TH.06.K5.171/2	SW	F.1374	LB IA	TIL 46	TH.06.K5.134/6	SW	F.1493	MB IB
TIL 14	TH.06.K5.171/4	SW	F.1374	LB IA	TIL 47	TH.06.K5.131/8	SW	F.1487	MB IB
TIL 15	TH.06.K5.171/1	SW	F.1374	LB IA	TIL 48	TH.06.K5.131/4	SW	F.1487	MB IB
TIL 16	TH.06.K5.174/7	SW	F.1364	LB IA	TIL 49	TH.06.K5.131/3	SW	F.1487	MB IB
TIL 17	TH.06.K5.174/4	SW	F.1364	LB IA	TIL 50	TH.06.K5.131/18	PW	F.1487	MB IB
TIL 18	TH.06.K5.174/2	SW	F.1364	LB IA	TIL 51	TH.07.M.502/17	SW	F.2207	LB IA
TIL 19	TH.06.K5.174/6	SW	F.1364	LB IA	TIL 52	TH.07.G.261/16	PW	F.1958	LB IA
TIL 20	TH.06.K5.198/8	SW	F.1421	MB IIB	TIL 53	TH.07.Q.422/17	KW	F.2093	MB II
TIL 21	TH.06.K5.198/3	SW	F.1421	MB IIB	TIL 54	TH.07.V.550	PW	F.2153	MB IA
TIL 22	TH.06.K5.198/6	SW	F.1421	MB IIB	TIL 55	TH.07.M.507	PW	F.2212	LB IA
TIL 23	TH.06.K5.198/7	SW	F.1421	MB IIB	TIL 56	TH.07.M.502/9	SW	F.2207	LB IA
TIL 24	TH.06.K5.198/2	SW	F.1421	MB IIB	TIL 57	TH.07.M.501/16	KW	F.2207	LB IA
TIL 25	TH.06.K5.198/9	SW	F.1421	MB IIB	TIL 58	TH.07.Q.428/14	KW	F.2077	LB IA
TIL 26	TH.06.K5.253/1	SW	F.1422	MB IIB	TIL 59	TH.07.K5.156/2	KW	F.2317	MB IA
TIL 27	TH.06.K5.253/2	SW	F.1422	MB IIB	TIL 60	TH.07.K5.167/12	KW	F.1893	MB IB
TIL 28	TH.06.K5.253/4	KW	F.1422	MB IIB	TIL 61	TH.07.K5.167/11	KW	F.1893	MB IB
TIL 29	TH.06.K5.253/5	PW	F.1422	MB IIB	TIL 62	TH.07.G.269/8	KW	L.1969	MB IB
TIL 30	TH.06.K5.196/3	SW	F.1417	MB IIB	TIL 63	TH.07.K5.156/10	KW	F.2317	MB IA
TIL 31	TH.06.K5.196/1	PW	F.1417	MB IIB	TIL 64	TH.07.K5.154/1	PW	F.2302	MB IA
TIL 32	TH.06.K5.196/4	SW	F.1417	MB IIB	TIL 65	TH.07.G.262/8	KW	F.1957	MB IB
TIL 33	TH.06.K5.196/5	SW	F.1417	MB IIB					

Table 1a Sherd number, class, locus, and date of pottery samples (sample TIL 30 not considered in the analyses because too small).

Sample	Sample number	Locus	Dating of context	Sample	Sample number	Locus	Dating of context
MATIL 14	TH.07.G.253*14	F.1950	LB IA	MATIL 103	TH.06.K5.143*103	F.793	MB IIB
MATIL 20	TH.06.K5.173*20	F.1365	LB IA	MATIL 111	TH.07.Q.410*111	F.2071	MB II
MATIL 49	TH.06.G.16*1	F.1223	LB IA	MATIL 112	TH.06.K5.142*112	F.1487	MB IB
MATIL 62	TH.07.K5.5*62	F.1704	MB IB	MATIL 136	TH.07.Q.432*136	F.2092	MB II
MATIL 67	TH.07.G.262*67	F.1957	MB IB	MATIL 158	TH.07.E.273*158	F.1984	Med.
MATIL 71	TH.07.Q.409*71	F.2067	MB II	MATIL 174	TH.07.E.280*174	F.1990	MB IB

Table 1b Mudbrick samples from various contexts (the number before the * is the bucket number, the one after the * is the sample absolute number of that year).

2.2 Analytical techniques

In order to allow a correct analysis, we removed all earth residues from the samples by abrasion with a diamond file. We obtained thin and/or polished sections from significant samples and examined them with optical and scanning electron microscopes (SEM Philips 515b, 15kV, BEI). These observations yielded a detailed mineralogical characterisation, mainly as regards certain specific mineralogical phases, that had been added to the sample, or were already present in the raw material.

After that, we pulverized all the samples by grinding them in an agate mechanical mortar. We then analysed the resulting dust to determine:

- mineralogical composition, by X-ray diffraction analysis (XRD) (Philips PW1710);
- chemical composition of major elements (10), and trace elements (15) by fluorescence to X rays (XRF) (Philips PW1480);
- thermal behaviour, by thermal analysis TG, DTG, DTA (Setaram Labsys), with a heating rate of 20°C/min, CO_2 atmosphere, and a heating range between 20° and 1000°C.

We used thermal analysis to quantify the samples' Loss On Ignition (LOI), rate within specific temperature ranges. Regarding LOI up to temperatures of 300°C (H_2O absorbed) to be too oscillating and random as a parameter, we did not include it in our chemical analysis. We ascribed LOI in the range between 600° and 1000°C to CO_2 bound to the calcite present in the material, and therefore used it to quantify this calcite. In order to compare the mudbricks, which were accidently burnt in a fire and therefore not homogeneously fired, with other fired products, we assumed the sampled ones to be water-free. Finally, to underline geochemical similitude and to test hypotheses as to the provenance of the samples, we processed the data using cluster analysis and binary diagrams.

3. RESULTS

3.1 Chemical analysis and statistical processing

Tables 2a, 2b, and 2c show our chemical analyses of the pottery and the mudbrick samples as regards their content of major elements, expressed in oxides (wt%), and 15 trace elements (expressed in ppm). We ordered the samples into four groups resulting from our cluster analysis. Our results are listed in the dendrogram in Fig. 1. (The major elements detected were SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO and K_2O, the trace elements V, Cr, Ni, Co, Zn, Rb, Sr, and Ba).

Group 1 is constituted of two subgroups (1a and 1b), which account for most of the SW samples, and 10 PW samples (the heavy type). The finds, although showing a quite homogeneous chemical composition and therefore a very close degree of relationship, differ substantially in their SiO_2, CaO and MgO contents, which are overall higher in Subgroup 1a, while Subgroup 1b shows higher contents of Al_2O_3, Fe_2O_3 and K_2O. As to the trace elements, we noticed basically higher Cr and Ni contents in Subgroup 1a (and in sample PW TIL 42 in Subgroup 1b), and very variable Sr contents (33-330 ppm) in both subgroups. Ba, La, and Ce are generally higher in Subgroup 1b. Moreover, SW samples TIL 20 and PW TIL 29, both in Subgroup 1a, show intermediate values between the two subgroups, as well as the above-mentioned properties.

Group 2 comprises all the mudbrick samples, except for a PW sample designated as TIL 6, with high contents of Fe_2O_3, Co and Zn.

Group 3 is constituted of 4 SW samples, 6 KW samples (in italics) and 1 PW samples (in bold). This group differs from the previous groups for its lower SiO_2, Zr, La, and Ce values, and basically higher MgO, CaO, and Sr values. Due to their high CaO content, samples SW TIL 26 and KW TIL 60 (represented by the discontinuous line in the cluster analysis) are also included in this group, in spite of their lower similarity degree.

Group 4 is formed of only 4 KW samples. It clearly differs from the other groups in chemical composition (CaO<4%, Al_2O_3<10%, K_2O<1%, MgO>10%, Fe_2O_3 between 11 e 13%, Co>80 ppm, Cr>2000 ppm, and Ni>1500 ppm). KW sample TIL 57 differs slightly from the other 3 samples. SW sample TIL 3 – represented by the discontinuous line in the cluster analysis – shows strongly anomalous levels of Cu and is hence not included in any of the four groups. This feature is probably due to sulphide impurities in the clay, or post-firing contamination. It is easier for archaeologists to detect such anomalies from direct examination of objects, because analyses are usually made on very little fragments, which sometimes are not totally representative of the sample they belong to. At any rate, if we had not taken Cu into consideration in our cluster analysis, the sample would have fallen within Group 1.

GROUP 1a																										
SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Sc	V	Cr	Co	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb	Ba	La	Ce
TIL 10	67.93	0.85	12.65	7.04	0.12	4.67	1.18	0.55	2.36	0.30	2.08	17	95	967	41	565	28	82	96	55	29	407	20	491	31	56
TIL 36	67.21	0.93	13.00	7.09	0.12	6.20	1.12	0.63	2.30	0.30	1.09	17	107	935	39	558	24	74	110	45	30	421	22	484	39	61
TIL 1	68.25	1.00	14.21	6.60	0.09	3.21	1.02	0.68	2.50	0.17	2.27	16	93	694	26	356	35	79	99	61	31	421	22	574	44	84
TIL 4	69.18	0.93	12.58	7.25	0.11	4.72	1.32	0.56	1.88	0.13	1.35	15	101	613	33	476	36	93	92	53	33	385	24	431	40	85
TIL 27	60.92	0.91	12.80	6.46	0.11	4.98	4.99	0.67	2.65	0.29	5.19	16	96	742	29	387	30	79	103	141	29	338	20	528	26	94
TIL 40	63.80	0.95	14.58	8.79	0.13	6.90	0.98	0.52	2.54	0.14	0.69	23	122	1240	52	752	27	94	118	33	30	285	23	533	37	80
TIL 41	62.97	0.98	14.39	8.78	0.13	7.34	1.21	0.59	2.44	0.17	0.99	19	123	1829	52	741	28	97	110	35	26	275	26	488	36	72
TIL 33	62.73	0.93	14.32	8.19	0.17	5.74	2.44	0.53	2.84	0.20	1.92	17	117	1444	46	583	28	92	111	67	26	264	18	562	32	91
TIL 37	61.73	0.87	13.72	8.68	0.16	6.59	1.64	0.51	2.47	0.36	3.28	22	115	1347	59	872	39	100	109	77	28	266	18	587	31	88
TIL 21	61.71	0.94	12.09	8.80	0.15	8.78	4.12	0.57	1.71	0.18	0.95	13	105	1169	49	780	31	89	82	83	29	347	23	474	32	91
TIL 56	63.81	0.99	15.10	8.55	0.18	5.05	1.23	0.47	2.48	0.29	1.84	18	98	944	49	795	24	98	90	30	28	419	22	573	21	62
TIL 2	65.99	1.08	14.91	7.73	0.13	3.15	1.17	0.59	2.95	0.20	2.09	22	120	481	37	416	61	78	111	68	30	308	26	565	40	77
TIL 51	68.53	1.22	13.57	7.11	0.15	2.15	1.12	0.54	2.25	0.83	2.53	15	95	285	32	365	59	76	73	71	25	314	24	762	31	56
TIL 49	65.83	0.98	16.03	6.93	0.10	2.43	1.53	0.66	3.36	0.23	1.91	19	108	320	21	203	30	87	129	68	32	315	23	708	31	89
TIL 14	60.05	1.20	14.46	8.43	0.18	5.31	5.03	0.55	2.16	0.42	2.18	19	150	366	37	261	35	110	104	210	26	294	24	642	45	73
TIL 32	59.11	1.34	14.80	8.95	0.20	5.15	5.19	0.59	2.20	0.43	2.05	16	138	437	42	321	32	126	92	186	29	284	25	658	39	94
TIL 9	61.57	1.27	15.44	8.76	0.15	4.10	2.17	0.60	2.51	0.45	2.99	23	136	478	44	314	39	111	97	156	33	336	30	614	44	78
TIL 38	58.06	1.18	14.51	8.09	0.15	7.75	3.30	0.56	2.62	0.42	3.36	19	130	309	32	274	41	106	89	167	30	307	25	590	38	79
TIL 13	55.27	1.16	14.50	8.37	0.15	7.17	9.14	0.65	2.23	0.42	0.94	14	119	362	36	280	40	112	115	278	31	310	24	554	36	97
TIL 35	55.24	1.25	15.03	8.94	0.16	6.87	8.60	0.65	2.36	0.21	0.70	18	121	373	40	276	36	109	102	247	30	283	25	592	54	93
TIL 24	59.52	1.28	13.49	8.30	0.16	4.95	7.49	0.66	2.00	0.23	1.91	14	122	340	33	204	31	102	87	251	36	320	23	503	32	71
TIL 7	**55.12**	**1.07**	**16.15**	**10.37**	**0.15**	**6.46**	**3.50**	**0.57**	**2.99**	**0.89**	**2.73**	**23**	**172**	**664**	**55**	**477**	**28**	**148**	**96**	**168**	**27**	**254**	**29**	**460**	**41**	**73**
TIL 39	61.42	0.94	13.53	8.16	0.18	6.91	3.95	0.54	2.32	0.36	1.70	22	127	1028	46	543	29	99	108	185	24	280	21	865	28	78
TIL 23	65.96	1.01	15.29	7.93	0.27	3.18	1.38	0.67	3.11	0.18	0.99	17	115	425	40	381	35	89	136	57	35	387	26	713	44	94
TIL 15	60.62	0.59	12.33	7.04	0.15	5.69	9.91	0.69	1.78	0.20	0.99	26	104	885	39	494	34	64	58	147	22	133	14	363	24	57
TIL 25	55.51	0.76	14.25	7.39	0.14	3.65	8.08	0.64	3.10	0.18	6.30	22	122	415	34	279	40	71	79	94	20	197	20	478	27	70
TIL 11	65.73	0.72	12.70	5.92	0.19	2.50	7.18	0.54	2.57	0.51	1.44	12	82	115	19	100	45	67	94	158	33	149	20	391	36	98
TIL 12	65.69	0.68	12.43	5.84	0.19	2.49	7.60	0.58	2.55	0.41	1.53	9	78	145	19	84	46	82	98	156	29	163	23	333	40	77
TIL 46	63.47	0.75	13.16	6.14	0.16	2.33	9.04	0.58	2.63	0.32	1.40	20	99	135	16	97	46	83	102	137	30	155	16	433	30	85
TIL 8	**63.79**	**0.83**	**15.45**	**6.82**	**0.13**	**2.54**	**4.71**	**0.59**	**3.27**	**0.66**	**1.25**	**13**	**111**	**109**	**18**	**85**	**42**	**96**	**135**	**149**	**32**	**182**	**25**	**365**	**37**	**87**
TIL 50	**67.81**	**0.72**	**13.57**	**5.90**	**0.14**	**2.39**	**4.43**	**0.59**	**3.04**	**0.33**	**1.08**	**18**	**96**	**101**	**16**	**85**	**31**	**78**	**122**	**123**	**27**	**166**	**20**	**449**	**44**	**99**
TIL 22	62.58	0.73	13.57	6.79	0.13	2.79	6.93	0.51	3.28	1.41	1.29	19	91	112	24	104	47	86	140	208	36	145	21	495	43	70
TIL 44	60.20	0.78	13.63	6.44	0.14	2.37	10.16	0.59	2.98	1.53	1.17	14	96	116	18	97	83	98	112	202	25	155	21	398	31	75
TIL 20	46.47	1.25	20.79	7.66	0.11	5.24	13.89	0.51	2.64	0.26	1.17	19	139	189	16	130	41	60	61	151	37	344	38	390	45	87
TIL 29	**50.65**	**0.96**	**11.31**	**6.69**	**0.14**	**7.44**	**10.85**	**0.51**	**1.90**	**0.16**	**9.40**	**15**	**123**	**395**	**27**	**327**	**40**	**76**	**70**	**327**	**29**	**334**	**22**	**419**	**37**	**75**

Table 2a Chemical analyses of the ceramic finds of Group 1a (major elements expressed as oxides wt%, and trace elements expressed as ppm). PW samples in bold.

GROUP 1b																											
SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Sc	V	Cr	Co	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb	Ba	La	Ce
TIL 52	**59.84**	**1.12**	**17.17**	**10.07**	**0.18**	**3.21**	**3.24**	**0.39**	**3.71**	**0.46**	**0.61**	**14**	**135**	**345**	**33**	**217**	**27**	**140**	**127**	**138**	**36**	**318**	**30**	**523**	**41**	**113**
TIL 64	**57.32**	**1.05**	**21.81**	**10.63**	**0.18**	**2.08**	**1.33**	**0.53**	**4.08**	**0.40**	**0.58**	**22**	**142**	**159**	**39**	**117**	**33**	**118**	**147**	**55**	**34**	**213**	**22**	**518**	**43**	**138**
TIL 16	52.24	0.97	19.35	8.24	0.20	4.71	6.89	0.80	3.64	0.90	2.06	20	131	333	33	202	35	111	136	303	33	192	26	607	53	95
TIL 48	52.28	1.04	20.68	8.73	0.18	4.53	4.63	0.84	4.02	0.29	2.80	20	144	293	31	197	32	119	149	242	33	189	29	752	54	130
TIL 19	56.43	1.09	21.26	9.17	0.12	2.17	4.32	0.66	3.21	0.39	1.17	22	157	171	31	101	29	98	145	162	33	260	28	612	60	123
TIL 34	**58.54**	**1.21**	**16.78**	**9.05**	**0.16**	**3.80**	**2.79**	**0.71**	**3.38**	**1.12**	**2.47**	**23**	**153**	**329**	**36**	**234**	**22**	**125**	**111**	**142**	**33**	**338**	**29**	**675**	**47**	**121**
TIL 18	58.84	1.14	20.52	9.57	0.16	2.29	1.66	0.84	3.70	0.32	0.95	23	162	223	39	132	42	133	158	90	38	215	24	651	55	115
TIL 43	57.02	1.21	21.75	9.89	0.13	2.17	1.11	0.86	3.97	0.40	1.50	29	165	206	34	129	33	131	168	81	35	225	26	643	56	148
TIL 45	56.21	1.21	22.03	9.91	0.18	2.21	1.64	0.96	3.91	0.49	1.23	28	158	182	37	114	34	135	165	87	44	228	27	662	69	137
TIL 55	**55.51**	**1.18**	**21.91**	**9.71**	**0.14**	**3.20**	**1.92**	**0.82**	**3.77**	**0.53**	**1.30**	**30**	**161**	**181**	**34**	**136**	**33**	**129**	**162**	**165**	**32**	**174**	**25**	**1058**	**60**	**113**
TIL 42	**52.50**	**0.88**	**16.85**	**9.41**	**0.21**	**7.64**	**5.74**	**0.63**	**3.30**	**0.66**	**2.17**	**22**	**124**	**821**	**55**	**639**	**57**	**111**	**125**	**269**	**29**	**158**	**20**	**622**	**45**	**115**
TIL 54	**50.84**	**1.49**	**27.34**	**12.66**	**0.15**	**1.65**	**0.59**	**0.42**	**3.14**	**0.43**	**1.29**	**28**	**135**	**197**	**41**	**151**	**42**	**137**	**110**	**27**	**38**	**305**	**31**	**599**	**58**	**125**

GROUP 2																										
SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Sc	V	Cr	Co	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb	Ba	La	Ce
MATIL 14	58.14	1.80	14.40	12.42	0.25	3.69	4.56	0.60	2.67	1.47	0.00	33	159	782	69	437	51	159	81	187	27	241	24	509	33	79
MATIL 111	56.59	1.90	15.57	13.09	0.23	3.52	5.26	0.61	2.40	0.82	0.00	27	175	706	63	386	55	160	66	201	29	239	27	425	40	70
MATIL 49	59.37	1.87	15.80	12.24	0.22	3.40	3.45	0.61	2.29	0.76	0.00	27	184	651	68	354	44	142	81	178	33	278	28	521	38	105
MATIL 20	60.15	1.48	12.65	11.03	0.23	4.11	4.99	0.58	2.76	2.02	0.00	24	138	991	67	550	56	184	83	241	28	237	27	462	31	72
MATIL 71	59.20	1.67	14.06	12.42	0.22	4.04	4.04	0.46	3.37	1.52	0.00	22	136	787	68	521	47	174	71	193	31	239	27	463	33	78
MATIL 158	57.15	1.57	12.75	11.81	0.22	4.70	7.09	0.62	2.53	1.56	0.00	20	150	890	63	552	57	177	64	202	22	179	19	420	32	71
MATIL 103	61.31	1.48	13.58	11.26	0.25	3.89	4.01	0.67	1.96	1.59	0.00	25	139	1010	64	590	74	230	83	196	24	207	22	493	34	72
TIL 6	**63.97**	**0.84**	**12.90**	**8.08**	**0.22**	**5.25**	**3.57**	**0.83**	**2.50**	**0.55**	**1.29**	**22**	**111**	**706**	**47**	**654**	**45**	**180**	**80**	**121**	**24**	**203**	**20**	**521**	**37**	**80**
MATIL 62	57.06	2.12	15.98	14.28	0.28	3.62	3.18	0.90	1.86	0.71	0.00	29	204	975	85	357	49	158	49	159	25	232	25	613	42	86
MATIL 136	54.16	2.41	17.59	14.81	0.31	3.02	4.73	0.60	2.07	0.30	0.00	32	251	649	84	265	48	140	56	158	29	251	28	501	35	117
MATIL 174	49.00	2.31	19.33	15.66	0.27	4.29	5.71	0.95	1.83	0.64	0.00	29	207	513	72	353	39	133	36	224	24	178	25	403	25	64
MATIL 67	54.97	2.14	17.94	14.53	0.25	3.00	2.45	0.58	3.33	0.82	0.00	31	203	599	78	348	59	179	112	129	35	297	30	564	42	108
MATIL 112	52.78	2.38	19.73	16.35	0.25	2.85	1.97	0.85	2.14	0.68	0.00	37	281	699	89	335	47	187	87	120	41	342	39	648	47	106

Table 2b Chemical analyses of the pottery finds and of the mudbricks of Groups 1b and 2 (major elements expressed as oxides wt%, and trace elements expressed as ppm). PW samples in bold.

GROUP 3																									
SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Sc	V	Cr	Co	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb	Ba	La	Ce
TIL 26	51.33	0.76	10.26	7.03	0.20	5.04	16.64	0.61	1.79	0.34	5.99	12	100	365	29	313	50	94	53	476	27	108	20	497	27	55
TIL 60	*38.62*	*0.69*	*9.85*	*6.19*	*0.23*	*2.71*	*22.63*	*0.36*	*2.03*	*1.28*	*15.41*	*13*	*91*	*179*	*18*	*186*	*44*	*83*	*53*	*456*	*21*	*101*	*17*	*544*	*29*	*52*
TIL 62	*42.83*	*0.35*	*19.48*	*10.37*	*0.17*	*6.86*	*11.63*	*0.58*	*1.18*	*0.23*	*6.34*	*39*	*118*	*639*	*70*	*277*	*37*	*54*	*28*	*110*	*7*	*5*	*8*	*341*	*4*	*14*
TIL 65	*44.74*	*0.56*	*17.74*	*8.52*	*0.17*	*5.50*	*13.59*	*0.80*	*1.16*	*0.07*	*7.16*	*35*	*166*	*312*	*39*	*200*	*43*	*49*	*18*	*85*	*15*	*11*	*9*	*223*	*6*	*23*
TIL 53	*49.70*	*0.26*	*19.70*	*7.83*	*0.15*	*10.75*	*6.60*	*0.75*	*1.35*	*0.14*	*2.76*	*30*	*105*	*817*	*46*	*392*	*48*	*49*	*14*	*137*	*6*	*0*	*4*	*274*	*4*	*18*
TIL 17	50.46	0.74	12.48	7.62	0.17	5.55	11.13	0.97	2.20	0.30	8.38	21	123	568	32	338	34	92	68	247	21	110	12	402	22	51
TIL 47	55.15	0.77	11.80	7.89	0.17	5.74	14.54	1.19	2.00	0.21	0.54	17	129	585	34	354	57	87	74	246	25	137	14	404	25	28
TIL 5	54.15	0.85	14.46	9.24	0.19	7.60	7.52	1.18	2.94	0.49	1.38	16	134	423	45	440	48	120	92	256	25	150	18	417	32	54
TIL 31	**59.75**	**0.89**	**12.02**	**8.94**	**0.16**	**6.97**	**7.32**	**0.96**	**1.66**	**0.23**	**1.11**	**16**	**129**	**991**	**43**	**554**	**45**	**105**	**56**	**227**	**29**	**147**	**20**	**381**	**36**	**54**
TIL 28	*53.06*	*1.36*	*17.93*	*10.81*	*0.21*	*6.53*	*6.27*	*0.97*	*1.47*	*0.23*	*1.17*	*31*	*185*	*1197*	*58*	*369*	*38*	*105*	*47*	*101*	*19*	*193*	*21*	*332*	*31*	*60*
TIL 58	*51.06*	*0.93*	*16.65*	*11.00*	*0.21*	*8.75*	*6.31*	*0.67*	*1.43*	*0.29*	*2.70*	*33*	*164*	*1419*	*70*	*533*	*45*	*93*	*30*	*100*	*12*	*92*	*15*	*476*	*20*	*42*
SAMPLE																										
TIL 3	54.24	0.84	16.22	8.72	0.18	8.21	4.66	0.67	3.18	0.29	2.80	16	139	727	53	615	147	114	120	252	29	158	21	542	42	112
GROUP 4																										
SAMPLE	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Sc	V	Cr	Co	Ni	Cu	Zn	Rb	Sr	Y	Zr	Nb	Ba	La	Ce
TIL 61	*51.96*	*0.37*	*7.70*	*13.60*	*0.21*	*16.71*	*3.17*	*0.33*	*0.98*	*0.14*	*4.82*	*23*	*120*	*3256*	*133*	*2349*	*36*	*91*	*30*	*51*	*10*	*36*	*9*	*173*	*8*	*21*
TIL 63	*51.66*	*0.38*	*7.02*	*13.21*	*0.23*	*16.95*	*2.81*	*0.36*	*1.00*	*0.22*	*6.16*	*23*	*122*	*3615*	*147*	*2488*	*31*	*96*	*29*	*33*	*6*	*38*	*8*	*199*	*12*	*21*
TIL 59	*49.34*	*0.38*	*7.47*	*11.87*	*0.20*	*20.11*	*3.93*	*0.37*	*0.78*	*0.18*	*5.38*	*19*	*113*	*4574*	*134*	*2170*	*37*	*95*	*18*	*30*	*11*	*112*	*19*	*130*	*11*	*21*
TIL 57	*61.17*	*0.70*	*8.98*	*11.05*	*0.16*	*12.72*	*1.47*	*0.40*	*0.83*	*0.39*	*2.13*	*15*	*85*	*2071*	*88*	*1677*	*40*	*116*	*33*	*38*	*13*	*124*	*12*	*279*	*25*	*45*

Table 2c Chemical analyses of the pottery finds and of the mudbricks of Groups 3 and 4 (major elements expressed as oxides wt%, and trace elements expressed as ppm). KW samples in italics. PW samples in bold.

Figs. 2, 3, and 4 illustrate binary diagrams for Al_2O_3/MgO, Fe_2O_3/Co and MgO/Cr, chosen to exemplify the chemical characteristics of each of the group highlighted by our cluster analysis. In particular, the Al_2O_3/MgO diagram shows that Group 4 (4 KW) stands out clearly from the others for its high MgO and low Al_2O_3 contents. The remaining samples, which constitute a homogeneous group, show a significant variability of Al_2O_3 content. In Fe_2O_3/Co diagram strong correlation between the two elements could be noticed in all samples, except those of Group 4. We also observed that mudbricks show the richest content of Fe_2O_3 and Co. Moreover the MgO/Cr diagram highlights, on the one hand, the strong homogeneity of the samples of the first three groups and, on the other, a meaningful correlation between the two elements in the Group 4 samples, where the contents of these elements are higher.

3.2 Mineralogical analysis

We performed X-ray diffraction (XRD) and thermal analyses (TG, DTG, DTA) on all samples. The latter revealed calcite percentages and thus clarified the nature of some mineralogical phases, such as those of chlorite, talc, and serpentine. We further observed some pottery finds and some mudbricks, whose mineralogical composition was hard to interpret with a polarizing microscope and a scanning electron microscope. These analyses provided a very detailed and thorough overview of the mineralogical composition of the samples.

3.2.1 Diffractometric data

Tables 3a and 3b show the data provided by our diffractometric analysis. The data is subdivided by type and rearranged according to the cluster analysis sequence. We attributed a semiquantitative estimate to each recognized mineralogical phase, reporting the relative contents of each individual sample. Our diffractometric analyses evidenced compositional trends in agreement with those revealed by the chemical analysis. Our data analysis evidenced that SW and PW samples of the first group present both compositional analogies and significant differences with respect to the Group 3 SW samples.

The first group samples are characterized by the predominance of the quartz phase, and after that by K-feldspars and plagioclases, which show variable contents ranging from significant to mere traces. Most of the samples also show clinopyroxenes and gehlenite – in quantities ranging from traces to significant – and traces of calcite, a small content of illite and micas, and a variable content of hematite.

Simple Ware																
Gr.	Sample	Qz	K-feld	Plg	Cpx	Geh	Hem	Magh	Ill/Mic	Amph	Cal	Chl	Opx	Serp	Talc	Oliv
	TIL 10	x x x x	tr	tr	tr		tr		tr		tr					
	TIL 36	x x x x	tr	tr	tr				tr	tr						
	TIL 1	x x x x	tr	tr	tr				tr		tr					
	TIL 4	x x x x	tr	tr	tr			tr	tr		tr		tr			
	TIL 27	x x x x	tr	tr	tr		tr		tr		x					
	TIL 40	x x x x	tr	tr	tr		tr		tr				x			
	TIL 41	x x x x	x	tr	tr		tr	x	tr				x			
	TIL 33	x x x x	tr	tr	tr				x		tr					
	TIL 37	x x x x	x	tr	tr						tr					
	TIL 21	x x x x	x	tr	x		tr				tr					x
	TIL 56	x x x x	x	x	tr				x		tr	x	tr			
	TIL 2	x x x x	x	tr	tr				x		tr		tr			
	TIL 51	x x x x	x	x					x		tr					
	TIL 49	x x x x	x	tr	tr		tr		tr							
	TIL 14	x x x x	x	tr	tr				tr		tr					
1a	TIL 32	x x x x	x	tr	tr		tr									
	TIL 9	x x x x	x	tr					tr		tr					
	TIL 38	x x x x	tr	tr	x		tr		tr		tr					
	TIL 13	x x x x	x x	x x	x x	x	tr				tr					
	TIL 35	x x x x	x x	x	x x	x	x									
	TIL 24	x x x x	x	x	x	tr	tr		tr		tr					
	TIL 39	x x x x	tr		x						tr		x			
	TIL 23	x x x x	tr	tr	tr	tr	tr		tr		tr					
	TIL 15	x x x x	x	x	x x	x			tr	x						
	TIL 25	x x x x	x	x	x		tr		x	x	x x					
	TIL 11	x x x x	x	x	x	x	tr		tr		tr					
	TIL 12	x x x x	x	x	x	x					tr					
	TIL 46	x x x x	x	tr	x	x	tr				tr					
	TIL 22	x x x x	x	tr	x	x			tr		tr					
	TIL 44	x x x x	x	x	x	x			tr		tr					
	TIL 20	x x x x	x x	x	x x	x x	x x		tr		x x					
	TIL 16	x x x x	x	tr	x	x	x		tr		tr					
	TIL 48	x x x x	x	x	x	x			x		x					
1b	TIL 19	x x x x	tr	tr	tr	x	tr	tr	tr		tr					
	TIL 18	x x x x	x	tr	x	x	x									
	TIL 43	x x x x	x	tr	tr		tr		x		tr					
	TIL 45	x x x x	x	tr	tr		x		tr							
	TIL 26	x x x x	x x	x x	x x x	x	x		x		x x					
3	TIL 17	x x x x	x	x x	x		x		x		x x x	x				
	TIL 47	x x x x	x x	x x	x x x x											
	TIL 5	x x x x	x x	x x	x x	x	x		x							
	TIL 3	x x x x	x		x		tr	x	x		tr					

Table 3a Semiquantitative mineralogical analysis obtained by XRD of SW samples. Qz = quartz; K-feld = K-feldspars; Plg = plagioclase; Cpx = clinopyroxene; Geh = gehlenite; Hem = hematite; Magh = maghemite; Cal = calcite; Ill/Mic = illite/mica; Amph = amphibole; Chl = chlorite; Opx = orthopyroxene; Serp = serpentine; Talc = talc; Oliv = olivine. xxxx very abundant; xxx abundant; xx significant; x modest; tr = traces.

Gr.	Sample	Qz	K-feld	Plg	Cpx	Geh	Hem	Magh	Ill/Mic	Amph	Cal	Chl	Opx	Serp	Talc	Oliv
PRESERVATION WARE																
1a	TIL 7	x x x x	x	tr	tr		tr	tr	x			tr				
	TIL 8	x x x x	x	tr	tr	tr	tr		tr		tr					
	TIL 50	x x x x	tr	tr			tr		tr							
	TIL 29	x x x x	tr	tr	x				tr		x x					
1b	TIL 52	x x x x	tr	x	tr		tr	tr								
	TIL 64	x x x x	x				x	x	x							
	TIL 34	x x x x	tr	tr					x							
	TIL 55	x x x x	x	x					x		tr					
	TIL 42	x x x x	x	tr	x		tr	x	tr		tr		x			
	TIL 54	x x x x	x				x	x	x		tr	tr	x			
2	TIL 6	x x x x	x	tr	x		tr		tr		tr					
3	TIL 31	x x x x	x	x	x	x	x			x	x					
KITCHEN WARE																
3	TIL 60	x x							tr		x x x x					
	TIL 62	x x x	x	x	x x				x	x x x	x x x x	x			x	
	TIL 65	x x	x	x x	x				tr	x x x	x x x x				x	
	TIL 53	x x	x	x x	x x					x x x x	x x	x x			x x	
	TIL 28	x x x x	x	x x	x x x				x	x	tr					
	TIL 58	x x x x	x x		x x x					x x x	tr	x				
4	TIL 61	x x x		x x x						x x x		x x x	x x	x x x x	x x	
	TIL 63	x x x x								x x x		x x x	x x	x x x x	x x	
	TIL 59	x x x								x x x x		x x x	x x	x x x		
	TIL 57	x x x x	x	x	x			x x			tr		x x			
MUDBRICKS																
2	MATIL 14	x x x x	x	x							tr					
	MATIL 111	x x x x	x	x	x x		tr		x		tr					
	MATIL 49	x x x x	x	x	tr				x		x					
	MATIL 20	x x x x	x x	x	x		x	x	x		tr					x
	MATIL 71	x x x x	x x	x			tr		x							
	MATIL 158	x x x x	x x x	x x			x			x	x x					x
	MATIL 103	x x x x	x x	x x	x	x			x	x x x	x	tr				
	MATIL 62	x x x x	x x	x x			x x		tr		x					
	MATIL 136	x x x x	x	x x					x	tr	x					
	MATIL 174	x x x x	x x x x	x x x	x x x	x x	x			x x		x		x x		x
	MATIL 67	x x x x	x	x			x		x							
	MATIL 112	x x x x	x	x	tr			x			tr					x

Table 3b Semiquantitative mineralogical analysis obtained by XRD of PW, KW, and mudbrick samples. Qz = quartz; K-feld = K-feldspars; Plg = plagioclase; Cpx = clinopyroxene; Geh = gehlenite; Hem = hematite; Magh = maghemite; Cal = calcite; Ill/Mic = illite/mica; Amph = amphibole; Chl = chlorite; Opx = orthopyroxene; Serp = serpentine; Talc = talc; Oliv = olivine. xxxx very abundant; xxx abundant; xx significant; x modest; tr = traces.

It is worth noting that in some samples the occurrence of maghemite, chlorite, enstatite, amphibole and olivine is scarce and sporadic. In the SW findings, belonging to

Group 3, our analysis highlighted a more abundant content of K-feldspars and plagioclases than in the previous samples. Moreover clinopyroxenes, gehlenite and calcite occurred in variable quantities (from absent to abundant). In particular, in sample SW TIL 47 the clinopyroxenes are very abundant, and we can suppose that they are prevalently of primary source because there is no good correlation. Sample PW TIL 6 – isolated in Group 2 – contains a prevalence of quartz, while the other phases, already showed in Group 1, are present in scarce quantities. In the mudbricks samples, all belonging to Group 2, the mineralogical composition is comparable to that of Group 1 samples, but gehlenite and clinopyroxenes are only sporadically present, while calcite is often widespread. The KW finds belong to Groups 3 and 4, and show strong compositional differences by comparison with the remaining sampling. In particular, we detected a great heterogeneity in quartz, feldspar, clinopyroxenes and calcite content in the finds of Group 3. Here the phases, which appeared only as traces in the other samples (amphiboles, chlorite, orthopyroxenes enstatite type, talc), are present in very abundant quantities, albeit not in all the samples. In sample KW TIL 60, instead, calcite constitutes the predominant phase.

The Group 4 finds, which displayed a marked chemical difference, have a completely different mineralogical composition from those of Group 3, with an abundance of amphibole, chlorite, enstatite, serpentine and talc (KW TIL 61). In sample KW TIL 57, the phases observed in the other three samples of Group 4, were not detected, except for a significant quantity of enstatite. We did not detect any gehlenite or hematite in either groups.[2]

3.2.2 Optical observations

In order to confirm and complete the diffractometric data, and address interpretative problems that cannot be completely solved with other investigations, we used a polarizing microscope to carry out further observations on some thin sections. In particular, we still lacked a clear understanding of the nature of the calcite abundantly present in the KW samples TIL 60, TIL 62 and TIL 65, and in some of the SW findings. The characterization of clinopyroxenes, which are very abundant especially in the KW samples of the third group and in SW TIL 47, was also an important clue to the origin of the samples, which was previously supposed to be primary. Our optical observations on

[2] It is well known that gehlenite and clinopyroxenes (diopside type) are Ca-silicates formed as secondary phases at high temperatures due to the reactions between carbonates and silicates present in the raw material. Their abundance is linked to the original high content of carbonate and to the firing temperature. Samples having high CaO content and Ca-silicate phases of high temperature in quantities from low to absent, but abundant presence of calcite, are considered to be ceramics fired at temperatures below 700-800°C. Instead, samples having high CaO content, abundant Ca-silicate secondary phases and calcite relics are considered to be artefacts fired at temperatures around 800-900°C. (Maggetti 1994; Veniale 1994; Minguzzi *et al*. 1995). However, clinopyroxenes can also be originally present (primary phases). In the first case the Ca and Sr contents are correlated, in the second they are not. The element Sr is geochemically compatible with Ca in carbonates and not in silicates; a good correlation between these two elements indicates that Ca-silicate high temperature phases mainly derive from carbonates of raw material.

sample KW TIL 57, on the one hand, confirmed the diffractometric data, and, on the other, highlighted the mineralogical phases which had not eluded our previous investigation.[3] Moreover optical observation revealed, for all the KW samples, a coarse grain size visible even to the naked eye. Pl. I: 3 shows a panoramic photomicrograph of sample KW TIL 62 where this characteristic is recognizable. As regards the nature of calcite, it is worth noting that in the KW samples TIL 60, TIL 62 and TIL 65 large sparry clasts with squared edges (probably added) are present (see Pl. I: 4-5); while in sample KW TIL 65 calcite is present in micritic clasts with sparry veins (Pl. I: 6). In some of the SW samples, where diffrattometric and thermal analyses revealed significant quantities of calcite, one can make out clasts of micritic calcite, sometimes of significant size, which were not completely destroyed by firing. Regarding the nature of the clinopyroxenes, in the examined KW samples of Groups 3 and 4 they are present as large crystals of augitic type and primary origin (Pl. II: 1); therefore in sample SW TIL 47, the origin of the abundant clinopyroxenes is predominantly primary.

Our optical observations of sample KW TIL 57, also conducted with an electron microscope, revealed the presence of large quartz clasts and chalcedony concretions (Pls. I: 1, II: 2). The presence of these phases explains the higher content of SiO_2 in the sample. This sample also includes some serpentinite clasts and, in the other samples of the fourth group, olivine replaced by serpentine (Pl. I: 2), and relic olivine crystals not detected earlier by the diffractometric analysis. In Group 3, we recognized the presence of lithic fragments (gabbros, diorites; Pl. II: 3). In the same group, we also observed that some of the mudbrick samples had a very heterogeneous composition. In addition to a fine fraction resulting from the clay component, we detected the presence of a coarse fraction formed by lithic fragments of quartz-feldspatic, carbonatic and ophiolitic nature, as well as isolated crystals of these types. In the mixture there were also impressions of vegetal residues (for other observations on mudbrick sample MATIL 20, cf. Bargossi *et al.* in press).

4. DISCUSSION AND CONCLUDING REMARKS

Our geochemical and mineralogical analyses provided detailed knowledge of the composition of the pottery artefacts and the techniques employed to manufacture them (firing temperature and treatment of the raw material). As to raw materials, our observations allowed to hypothesize an origin for them, based on comparisons with the mudbricks and with the geolithologic situation of the Tilmen Höyük area. Our analyses show that the SW and PW samples show similarities both in composition and in grain size (medium coarse), as autoptic analysis had already suggested. The KW samples

[3] We would like to underline that illite, mica and other layer silicates cannot always be identified appropriately by diffractometric analysis, because their structure is damaged during firing. Moreover the mineralogical phases present in low quantities (<3%), or semi-amorphous phases are not detectable with this analytical methodology. The presence of these minerals is better detected through by optical microscopy and by scanning electron microscopy.

differ from the aforementioned pottery class for their composition, their coarse grain size, and for the traces of blackening due to their use.

4.1 Composition

From our analyses of the data reported in the previous sections, we can deduce that most of the SW and PW samples show a fairly homogeneous composition, even though there are changes in some of the contents of the major and trace elements. These variations could depend on the contribution of raw materials of different nature, and also on artificial processing. Four SW samples and one sample of PW have different compositions and show geochemical affinity with a group of KW samples. Sample PW TIL 6 is isolated in the mudbrick group. The KW samples do not have compositional homogeneity with the SW and PW samples (with the exception of the above mentioned five SW samples), and are divided into two groups with different mineral-geochemical characteristics. Within the two groups, sample KW TIL 57 shows anomalous compositional characteristics. Since this artefact is dated to the LBA, whereas the other three are dated to the MBA, only further examination of case studies of contemporary samples could explain why this is the case. Even sample KW TIL 60, as mentioned above, has a composition that is much richer in calcite than that of the other KW samples.

4.2 Manufacturing techniques

4.2.1 Treatments

Regarding the SW samples, it is possible to infer that in some cases their characteristics were modified by human processing. Our analyses revealed primary crystals of clinopyroxene and calcite micritic clasts, which were probably added. In the PW samples, the low content of calcite may be due either to the original characteristics of the material or to depuration. The potters perhaps wanted to obtain products that were less porous and hence more suitable for food preservation. The KW samples show, as we mentioned above, very different characteristics compared to the other two ceramic classes. Our optical and diffractometric analyses revealed mineral phases, either in single large crystals or in lithic fragments, which were not found (or found only in traces) in the SW and PW samples. This characteristic is common to KW from the Mediterranean basin area. In this area, where kaolinitic clay – excellent refractory clay for KW manufacturing – is scarce, the Kitchen Ware was made with a predominantly illitic clay, more or less carbonatic and rich in Fe compounds, which was also used for other ceramic types. A lot of temper material, constituted by large crystals and lithic clasts of varied nature (ground calcite, quartz sand, pyroxenes, volcanic materials, etc.), was subsequently added to this clay. The aim of this technique was to obtain coarse mixtures with great porosity, low shrinkage and low thermal conductivity. These characteristics made the pottery suitable for standing the thermal shocks related to their use, and allowed slower cooking (Cuomo di Caprio 2007; Olcese 1994b; Olcese, Picon 1994).

4.2.2 Firing temperature

As regards firing temperatures, the SW and PW samples including gehlenite, secondary clinopyroxenes and calcite wrecks were fired at a temperature certainly >800°C. Whereas the firing temperature is <800°C when a greater quantity of calcite is present in the samples, and the gehlenite and secondary clinopyroxenes are low or absent (cf. no. 1). However, we must consider that in the samples derived from a raw material, which is poor in carbonate and has a low CaO content, the silicatic phases of high temperature formation are low. In these cases it is difficult to determine the firing temperature with any degree of accuracy. The firing temperature of the KW samples was certainly lower, because in the analyzed samples phyllosilicate and carbonate mineral phases are still present, which did not change their nature. For this ceramic class, the aforementioned authors indicate firing temperatures <700°C. The choice of firing temperature was hardly haphazard, on the contrary, it was carefully planned. At higher temperatures ceramic components have reactions that can change the technological characteristics of pottery types.

4.3 Provenance

The Tilmen Höyük geological area is lithologically very rich and varied. There are outcrops of Plio-Quaternary age basalts emplaced over Paleozoic lithostratigraphic units, formed by Mesozoic carbonatic and quartz-sandy sediments and units, with carbonatic sediment and ophiolites with gabbros, ultramafites and chromitites (cf. Bargossi *et al.* 2013). In addition to the rocks in place, there are also incoherent sediments with variable grain size (sand and clay), resulting from the erosion, the transport and the sedimentation of the substrate. Very heterogeneous materials were therefore available to the potters, and used for ceramic artefacts with different characteristics. A very important aim of this research was to ascertain whether the materials of the ceramic artefacts under study were local. Our mineralogical study of the mudbricks, which we chose as a reference as one can safely assume that they were locally produced, revealed a coherent composition with contributions of raw material of different nature formed from lithotypes present in the area.

Our cluster analysis of the entire sample placed the mudbrick samples in a separate group, which is strongly related to the group including PW samples and almost all the SW samples (with the exception of five samples mentioned above). Therefore for these samples we assume a derivation from local raw materials in different proportions: predominantly quartz-feldspatic for samples with higher Al content, ophiolitic for samples with significant Fe_2O_3, MgO, Cr and Ni contents, and carbonatic (probably in part added), for samples with higher CaO amount. Five of the SW samples are of local provenance, but they derive from a more carbonatic material, originally present or added as temper.

Regarding the KW samples, they have a composition which differs from the other two ceramics classes. One group is less connected to the group of mudbricks, while another group (4 samples) is clearly distinct from it. The first group is characterized by the presence of carbonatic material and scarcer ophiolitic contribution; while for the second group a clear ophiolitic nature contribution was detected. Therefore we can assume a local provenance for this ceramic class, too. Sample KW TIL 57 has a lithological composition that was not found in the area, but we cannot rule out that it is equally of local origin. Ancient potters chose raw materials with a suitable composition for the making of artefacts with specific technological characteristics.

In addition to all these considerations, there remains to be explored the possibility of a relationship between the composition, the manufacturing techniques and the dating of the pottery samples. In the analysed samples, correlations of this type were not observed. However, if we expand the sampling, especially for the PW and KW types, we may come up with different kinds of answers to the same question.

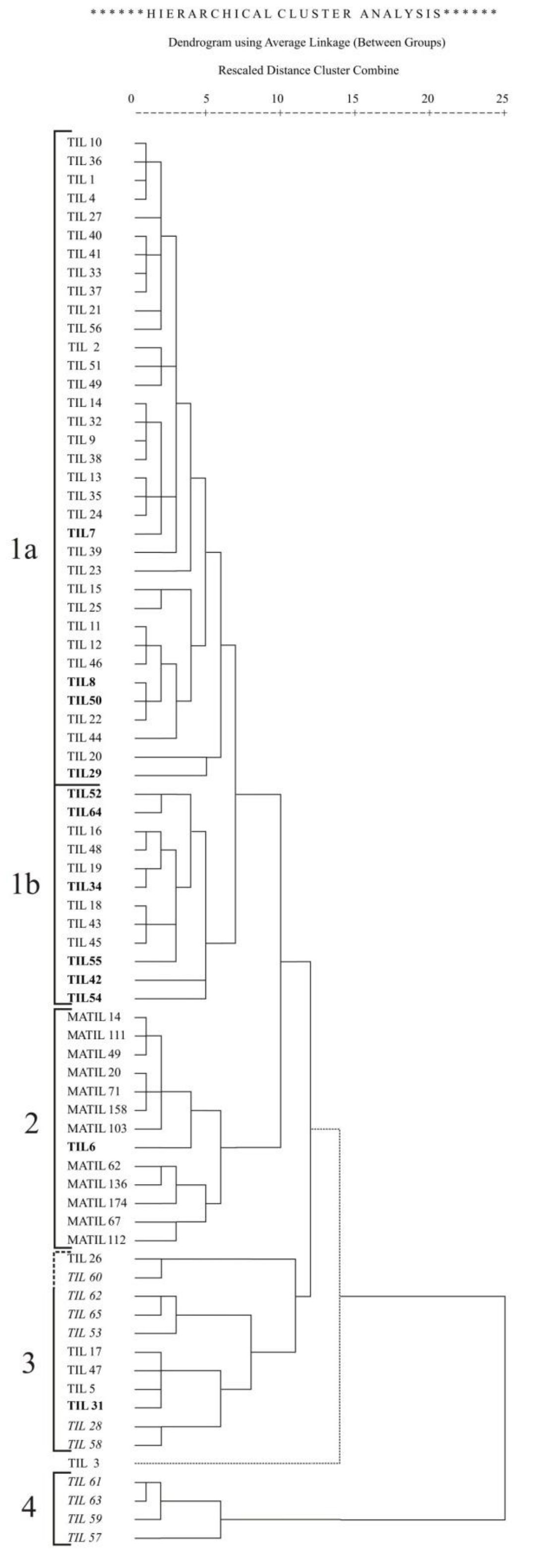

Fig. 1 Dendrogram of the cluster analysis. KW samples (italics), PW samples (bold).

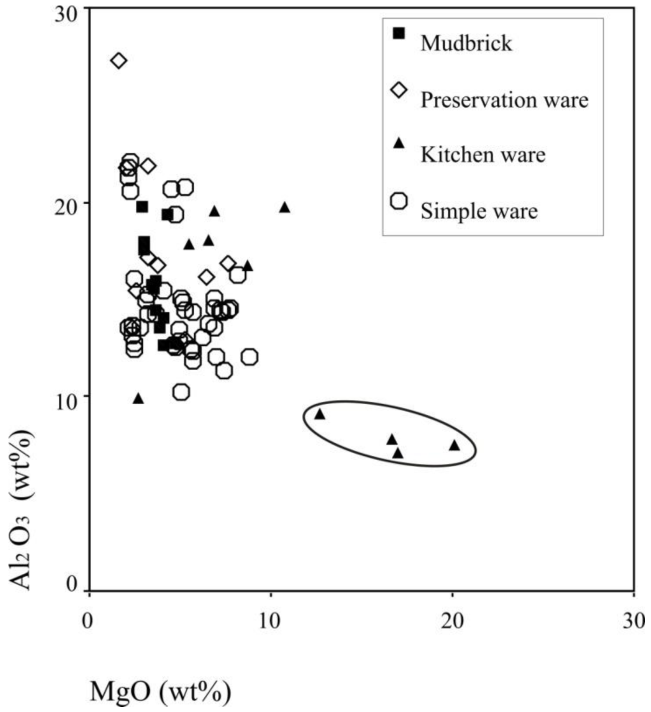

Fig. 2 Binary diagram MgO/Al_2O_3.

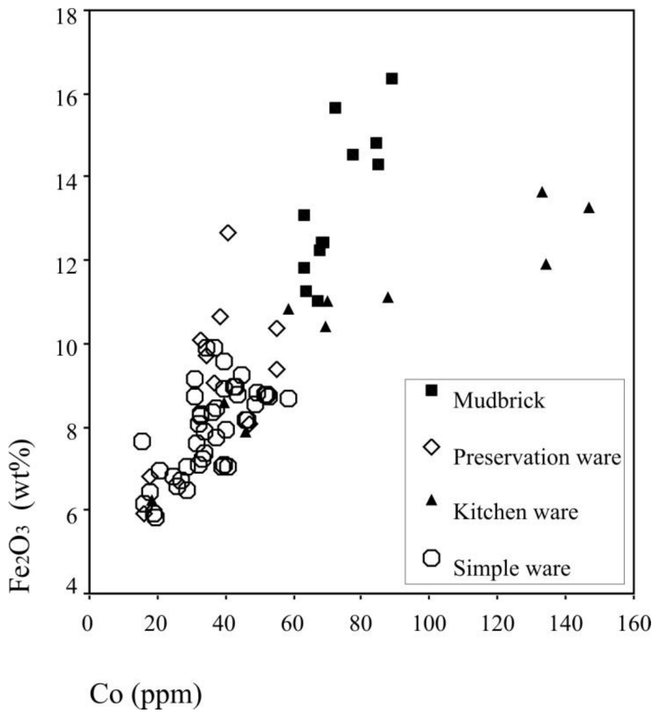

Fig. 3 Binary diagram Co/Fe_2O_3.

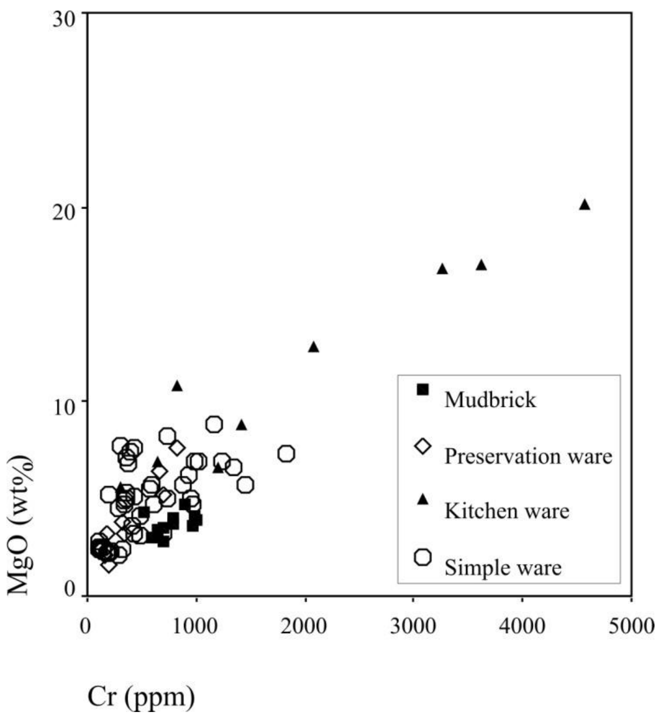

Fig. 4 Binary diagram Cr/MgO.

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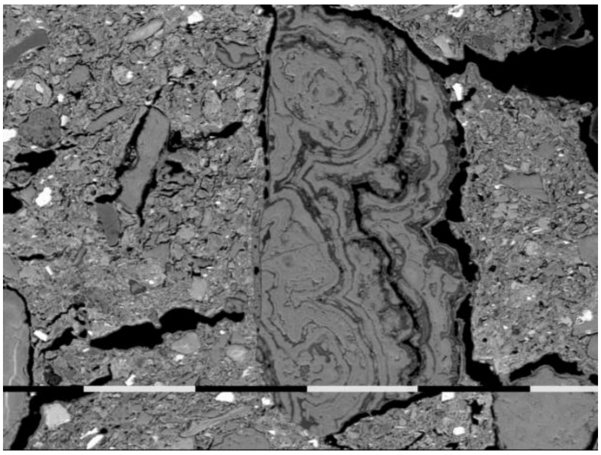
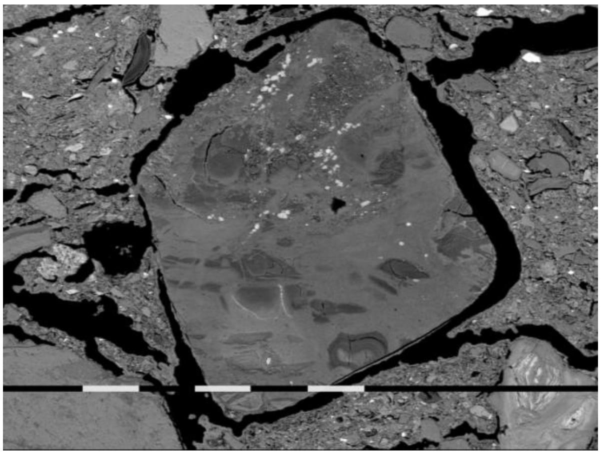
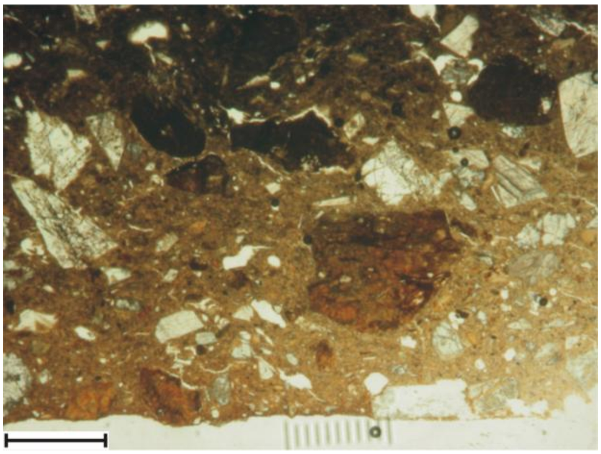


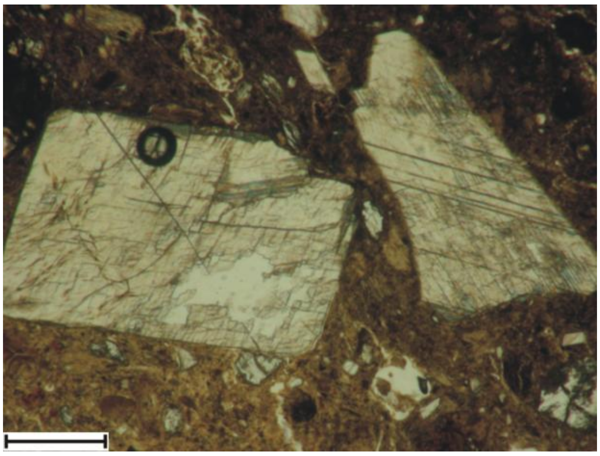
1 SEM image of chalcedony in sample KW TIL 57 (BEI, bar scale=0.1mm).



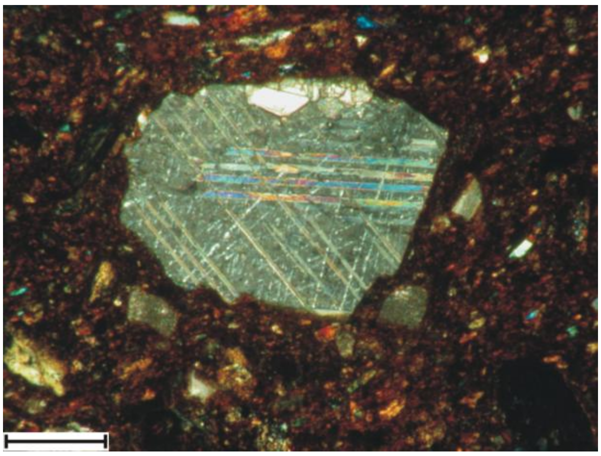
2 SEM image of serpentinized olivine in sample KW TIL 57 (BEI, bar scale=0.1mm).



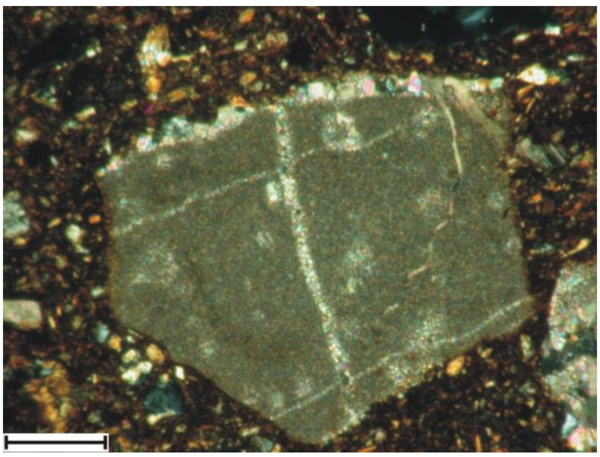
3 Panoramic photomicrograph (plane-polarized light, bar scale=1350 μm) of sample KW TIL 62.



4 Photomicrograph of calcite sparry clasts (plane-polarized light, bar scale=400 μm) in sample KW TIL 62.

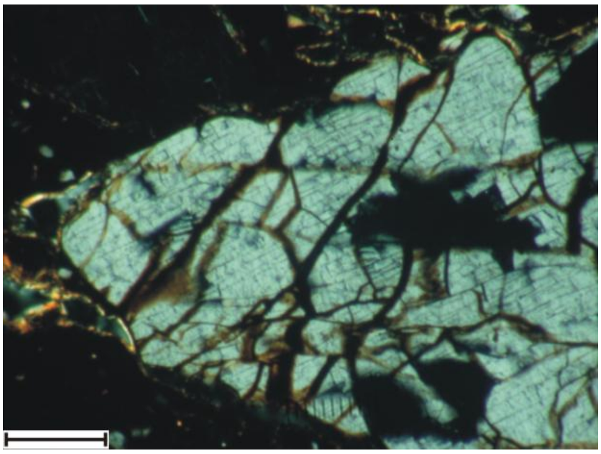


5 Photomicrograph of calcite sparry clast (crossed-polarized light, bar scale=400 μm) in sample KW TIL 65.

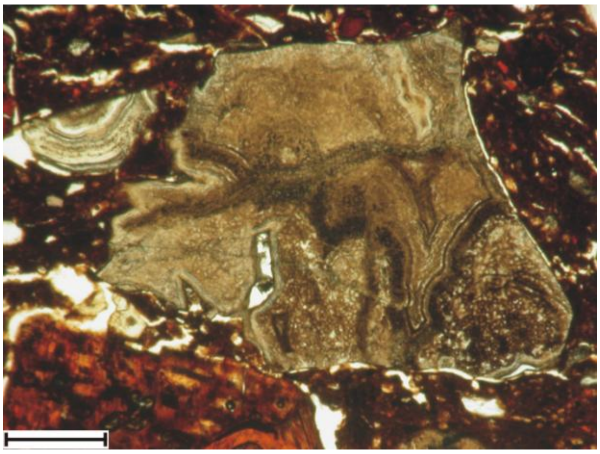


6 Photomicrograph of calcite micritic clasts with sparry veins (crossed-polarized light, bar scale=400 μm) in sample KW TIL 65.

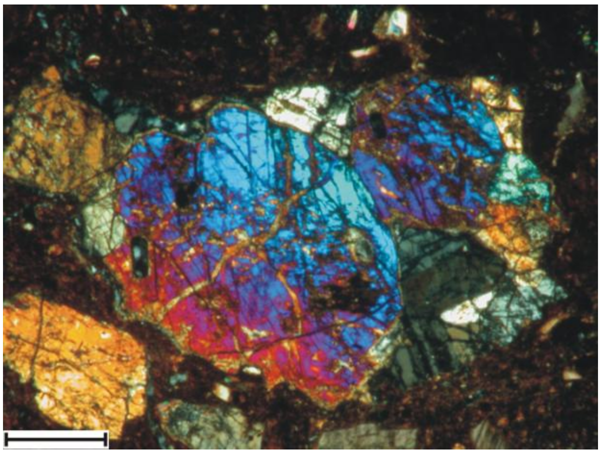
Pl. II



1 Photomicrograph of clinopyroxene (augitic type) crystal (crossed-polarized light, bar scale=250 µm) in sample KW TIL 57.



2 Photomicrograph of chalcedony crystal (plane-polarized light, bar scale=650 µm) in sample KW TIL 57.



3 Photomicrograph of gabbro fragments (crossed-polarized light, bar scale=650 µm) in sample KW TIL 62.