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LOCAL MATTERS: POTTERY PRODUCTION AT TELL HALAF AND TELL TAWILA

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Los fragmentos cerámicos de los periodos Halaf y Ubaid de Tell Halaf, Tell Tawilla y de la región de Tell Chuera han sido analizados utilizando métodos geoquímicos, mineralógicos y petrográficos. El intercambio y las importaciones ceràmicas seran discutidos y los fragmentos cerámicos Samarra de Tell Halaf se podran associar a producciones principamente locales.

Cerámica Halaf, Tell Halaf, Tell Tawila, Análisis petrográfico y mineralógico, Fluorescència de Rayos X.

Sherds of the Halaf and Ubaid periods from Tell Halaf, Tell Tawila and Chuera region were analysed through geochemical and mineralogical/petrographical methods. Pottery exchange and imports will be discussed and Samarra-like sherds from Tell Halaf, partly interpreted as imports, will be assigned as local products.

Halaf Pottery, Tell Halaf, Tell Tawila, Petrography and Mineralogy, X-Ray Analysis.

INTRODUCTION

Pottery sherds from Halaf and Ubaid periods were recently analysed within the framework of excavations at Tell Tawila and Tell Halaf in cooperation with colleagues from the University of Frankfurt/Main and the Karlsruhe Institute of Technology.

Both sites are located in Upper Mesopotamia in north-eastern Syria (Fig. 1), situated about 60 km apart and separated by a watershed. Especially during the Late Neolithic Halaf culture in the early 6th millennium cal. B.C., both sites share a lot of common features in the material culture (tholoi, painted fine ware, figurines; *cf.* Akkermans 1993; Becker 2011), yet based on the geographical setting and ecological conditions, some significant differences are indeed noticeable.

Accordingly, the Tell Halaf settlement starts during the Pottery Neolithic from about 6500 cal BC onwards (*cf.* Hole 2001: 70) and continues through all stages of the Halaf period, followed by the Ubaid period, while the prehistoric sequence ends with the Late Chalcolithic era. During the new excavations, solely the developed Halaf phases (Halaf IIa/b and the Halaf-Ubaid-Transitional (HUT) could be uncovered on a larger scale (Becker 2009, 2012, 2013a/b, 2015, 277–326).

Differing from Tell Halaf in the well-watered Khabur triangle, Tell Tawila and the Tell Chuera region – as part of the halafian '*hinterland*' – were intensively settled only after

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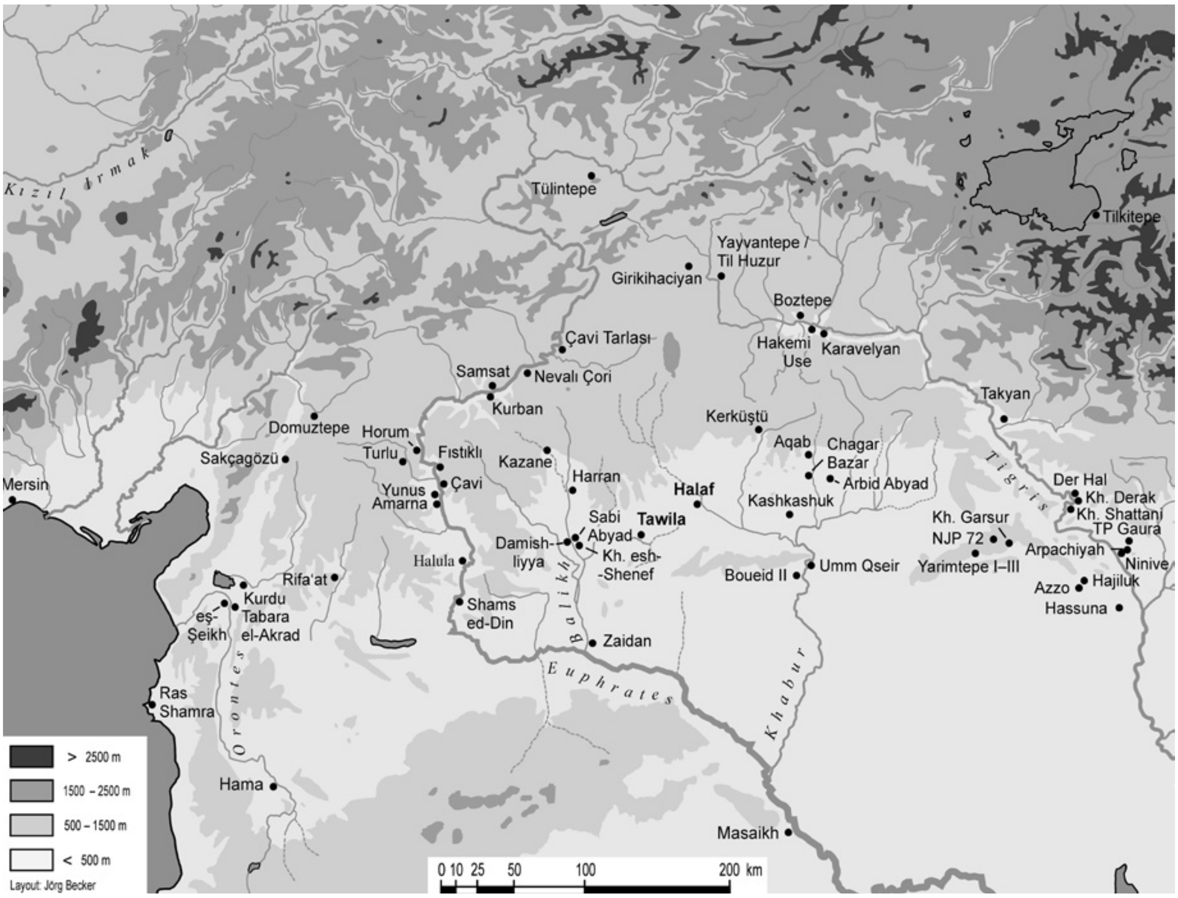


Figure 1. Map of Halafian sites.

the Halaf culture had become established along bigger rivers, emerging out of the older stages of Pottery Neolithic (henceforth, PN) with dates for Tell Tawila between ca. 5950–5650 cal BC. Further, in the subsistence of sites like Tell Tawila, the hunting of onager and gazelle played a more important role (Becker *et al.* 2007; Becker 2015).

Exchange between both regions can be suggested through recent X-ray analysis of obsidian from both sites, most of it coming from Bingöl A and B. The high percentage of obsidian in the lithic assemblage from Tell Tawila (ca. 40%) is very close to that of sites in the Khabur or the Sinjar region (Tell Umm Qseir with ca. 42%, Tell Aqab – 80%, Yarimtepe II – ca. 34%; *cf.* Campbell 1992, 152 with Tab. 8.8). Although the way via the Balikh valley cannot be excluded, the route via Tell Halaf as a possible transfer site seems most likely, whereas obsidian came into the Tell Chuera region as prepared cores (*cf.* Helms in Becker *et al.* 2007, 246 ff.; Becker 2015, 200).

QUESTIONS AND ANALYTICAL METHODS

Archaeological work on pottery is mainly based on the arrangement of wares, the typology of forms and decorative motifs, as well as their classification in chronological and spatial terms. Alongside this usual work, different kinds of archaeometric methods for the analysis of pottery have entered the scientific discussion during the last decades (*cf.* Moorey 1999, 149–153). In contrast to the traditional macroscopic descriptions of pottery and their fabrication, these archaeometric methods offer new insights concerning the raw materials and technologies employed, as well as aspects of communication and exchange, social organisation or specialisation (*cf.* Spataro 2002, 36; Spataro/Fletcher 2010, 95).

The examinations discussed in this article focused mainly on the following questions:

- questions about the sources of clay used, their possible preparation, especially in the case of the dominating painted fine wares.
- questions about similarities or dissimilarities in pottery fabrication on a local (intra-site level) and a regional level (inter-site level).

Sites	Total Samples	Periods			
		Pre-Halaf	Halaf	Ubaid	LC (and others)
Tell Halaf	32	1	25	6	–
Tell Tawila	40	–	26	4	10
WHS 5	12	–	10	1	1
WHS 15	11	–	5	4	2
WHS 19	4	–	3	–	1
WHS 21	5	–	5	–	–
WHS 23	5	–	5	–	–
WHS 28	7	–	1	2	4
WHS 42	7	–	4	–	3
Total	**123**	**1**	**84**	**17**	**21**

Figure 2. Distribution of analysed samples per site and period.

- questions about pottery exchange and specific production centres.
- questions about the pigments used for the painting and the required technologies (in progress).

To answer these questions, a combination of different archaeometric analyses was used. The aim of portable energy dispersive X-ray fluorescence analysis (pXRF) was the destruction-free analysis of a larger group of pottery samples from different sites and mainly from the Halaf and Ubaid periods, thus gaining a chemical fingerprint of these samples and an initial grouping.

Through the subsequent mineralogical and petrographic analyses, thin sections, scanning electro microscopy, and X-ray diffraction, of selected sherds, the composition of the samples, their similarities and differences were further studied (*cf.* for similar methods see also Spataro/Fletcher 2010, 95 f.). In several meetings, the results of these analyses were finally discussed with reference to their cultural and historical background.

ARCHAEOLOGICAL CONTEXT AND SAMPLING METHOD

The distribution of the samples is shown in Figure 2. In general, the samples focus on Halaf pottery with 84 samples, while only 17 pieces date to the Ubaid period. They were augmented by 21 sherds of the local Late Chalcolithic period and one sample of the *altmonochrom* stage from Tell Halaf (Fig. 2).

No samples from the recent excavations were available for Tell Halaf. Therefore, samples were taken from the old excavations undertaken by Max von Oppenheim before and after the First World War, now stored in different depots in the Vorderasiatisches Museum in Berlin. Based on earlier classifications of this pottery with its chronological external comparisons (*cf.* Becker 2013a, 47–53 fig. 2; Becker 2013b, 456–460 fig. 41.2 and 41.3), 32 samples were chosen for analysis. Thereby, the sample selection refers to potsherds first published by H. Schmidt (1943 in von Oppenheim), whose provenience from Tell Halaf can be regarded as secure. These samples should be more or less representative

Sample-No.	Reference after Schmidt 1943: Taf. ...	Ware	Dating	Comments
TH 1	XLII, 15	Ba	Halaf II	monochrome painted
TH 2	XLII, 6	Ba	Halaf II	*ibid.*
TH 3	LIX, 3	Ba	Halaf Ib-II	*ibid.*
TH 4	XC, 1	Ba	(Proto-Halaf /) Halaf Ia	*ibid.*
TH 5	XLIV, 13	Ba	Halaf	*ibid.*
TH 6	XLIV, 4	Ba	Halaf	*ibid.*
TH 7	LI, 3	Ba	Halaf II	*ibid.*
TH 8	XLV, 4	Ba	Halaf II	*ibid.*
TH 9	XLII, 12	Ba	Halaf II	*ibid.*
TH 10	L, 8	Ba	Halaf II	*ibid.*
TH 11	XLIII, 11	Ba	Halaf II	*ibid.*
TH 12	XLIII, 7	Ba	Halaf II	*ibid.*
TH 13	XLVIII, 12	Ba	Halaf II	*ibid.*
TH 14	LXXVII, 3 = XVI, 5	Ba	Halaf II	*ibid.*
TH 15	XLIV, 5	Ba	Halaf Ib-II	*ibid.*
TH 16	XLIV, 2	Ba	Halaf II	*ibid.*
TH 17	XC, 16	Ba	Halaf Ia	*ibid.*, Samarra influence
TH 18	XC, 7 = Abb. 57	Ba	Proto-Halaf / Halaf Ia	*ibid.*, Samarra influence
TH 19	XC, 13 = Abb. 54	Ba	Proto-Halaf / Halaf Ia	*ibid.*, Samarra import
TH 20	LXXXIX, 1	Ba	Halaf IIb ?	white painting on black varnish
TH 21	XCI, 2	Bb	Halaf IIb	polychrome painted
TH 22	LXXXIX, 7	Ba	Halaf IIb	monochrome painted
TH 23	XCI, 3	Bb	Halaf IIb	polychrome painted
TH 24	XLV, 12	Bb	Halaf IIb	polychrome painted
TH 25	LXXXVIII, 3	Ba	Halaf	plastic decorated fragment of a *'Korbgefäß'*
TH 26	XCVIII, 5 = XXX, 8	Ca	Halaf IIb / HUT	monochrome painted
TH 27	XCVII, 1 = Abb. 74	Aa	Pre-Halaf	*'altmonochrom'* with monochrome painting
TH 28	XCIX, 6 = XXXII, 13	Cb	Ubaid	polychrome painted
TH 29	CII, 8	Cb	Ubaid	monochrome painted
TH 30	CII, 3	Cb	Ubaid	*ibid.*
TH 31	CII, 5	Cb	Ubaid	*ibid.*
TH 32	CII, 7	Cb	Ubaid	*ibid.*

Figure 3. List of the analysed fine ware sherds from Tell Halaf.

for the spectrum of the fine ware pottery at Tell Halaf, including its time range. At the time of its selection, this museum collection focused on predominant and special fragments of the fine ware groups, whereas samples of coarse wares – at least in their present-day state – seem to be less represented, and therefore are not included in the analysed samples (Fig. 3, Fig. 4).

Figure 4 shows some of the selected sherds from Tell Halaf, starting with a painted *altmonochrom* example, viewed by H. Schmidt as an imitation of Halaf pottery, but it belongs to the oldest, local stage of the earlier Pottery Neolithic. Schmidt considered other samples as imitations or imports of the Samarra culture. Nevertheless, the majority of the selected sherds belong the to monochrome and polychrome painted Halaf ware groups. At the end of this selection one sample of red ware with black painting, often assigned to the Halaf IIb or Halaf-Ubaid-Transitional stage (henceforth, HUT), and some fragments representing the following Ubaid stages with monochrome and polychrome samples are presented (see also Fig. 3 for reference of the selected samples to the publication of H. Schmidt 1943 in von Oppenheim, and *cf.* Becker 2013b for actual comparisons).

The Halaf samples from Tell Tawila derive mainly from excavations. The Ubaid sherds from Tawila as well as the Halaf and Ubaid sherds are from all other Wadi Hamar sites found during the survey. Here as well, the selected samples mainly concentrate on the Halaf and Ubaid

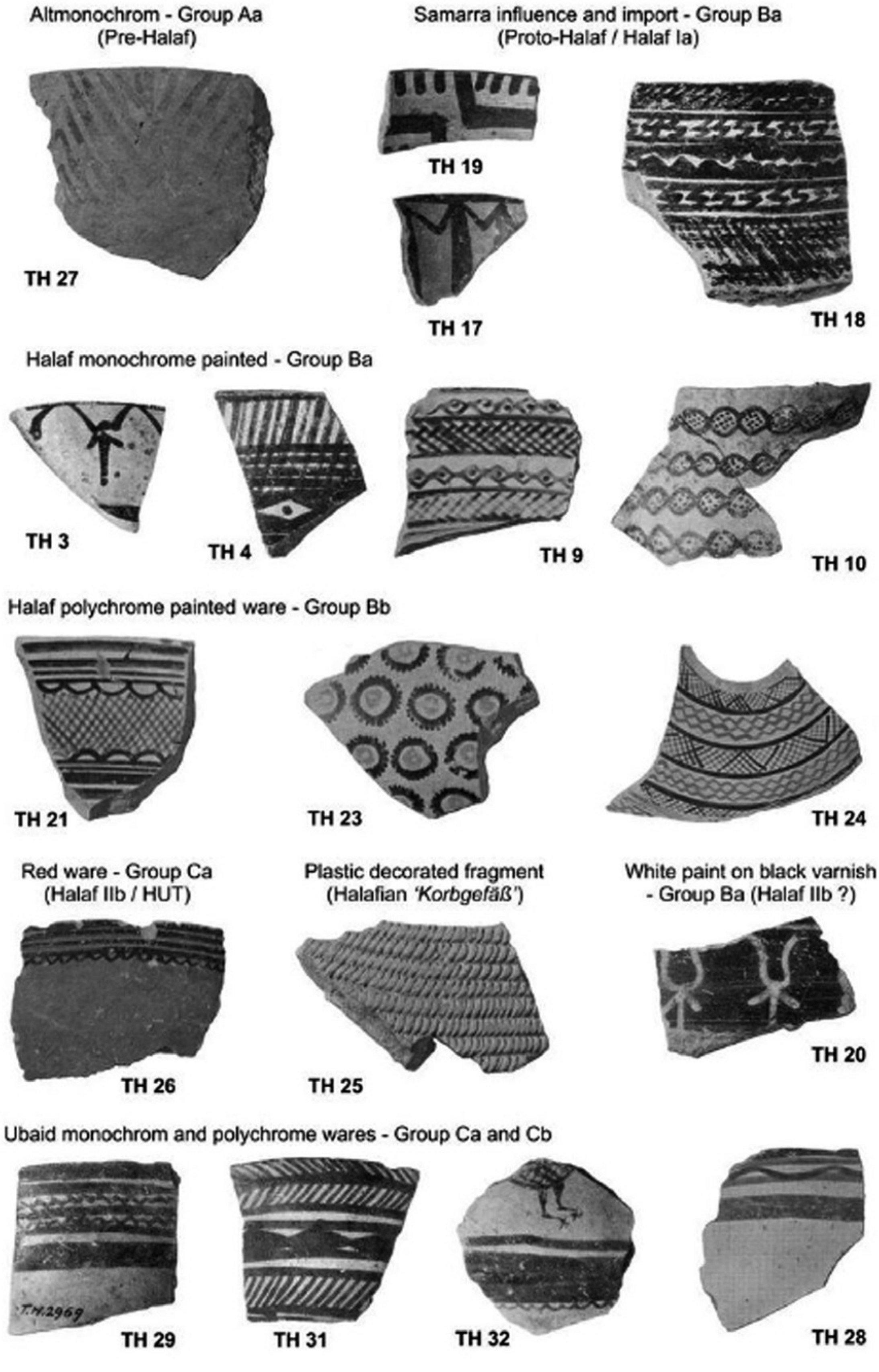


Figure 4. Selected fine ware samples from Tell Halaf illustrating their assumed time range (all photos after Schmidt 1943; *cf*. Tab. 3).

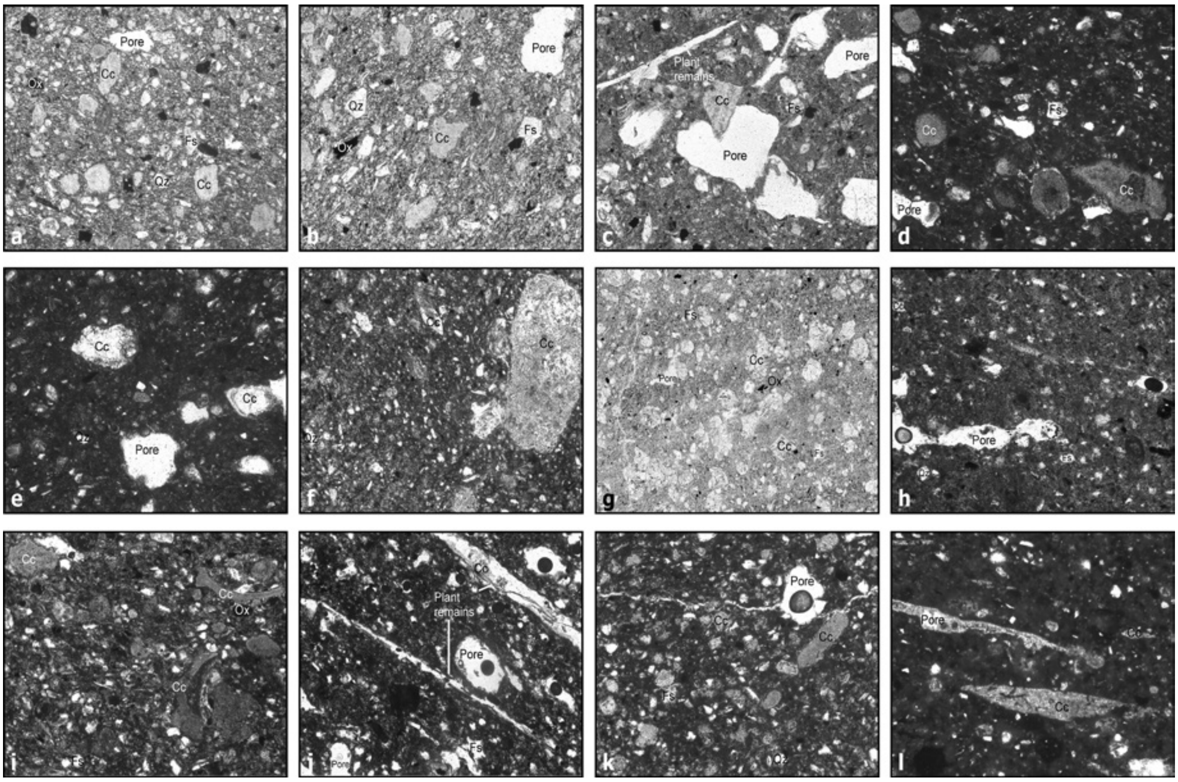


Figure 5. Microphotographs of fine ware samples from Tell Halaf (a–d), Tell Harubi (e), Mishrife (f), Agila-South (g–h), Khirbet Hagg Badran (i–j) and Tell Tawila (k–l): a, d, h, j, l = Ubaid pottery, b–c, e–g, i and k = Halaf pottery; plane polarised light, 1.2 mm field of view (abbrevations: *Cc* Calcite, Fs Feldspar, *Ox* Fe-Ti-Oxide, *Qz* Quartz).

monochrome fine wares. However, for the Halaf (n = 7) and the Ubaid (n = 5) periods some samples of kitchen wares are represented, i.e. the mineral-tempered kitchen ware of the Halaf and the chaff-tempered kitchen ware of the Ubaid period from Tell Tawila and other survey sites, which seem to be local products, and could be included in the sample list. No special fragments of bichrome or plastic decorated Halafian fine ware, which occur at Tell Tawila only in minimal quantities, could be incorporated in the analysed samples (*cf.* Helfert 2015 with addendum 4).

MINERALOGICAL AND PETROGRAPHICAL ANALYSIS

Thirty sherds from different sites (Tell Halaf, Tell Harubi, Mishrife, Khirbet Hagg Badran, Agila-South and Tell Tawila) were selected for mineralogical and petrographical analysis using thin sections, polarisation microscopy, X-ray diffraction, scanning electron microscopy, and electron microprobe analysis (*cf.* Drüppel 2015).

Macroscopically, the sherds of these sites display different colours and gradients in their core and marginal areas. Halaf sherds from Tell Halaf are characterised mainly by reddish-brown surfaces and pale green to pale red core areas. In contrast, Ubaid fragments from Tell Halaf and Tell Tawila have instead a homogenous red-brown colour, indicating oxidising conditions during firing. Samples from Tell Harubi, Mishrife, Khirbet Hagg Badran and Agila-South show heterogeneous colours; frequently uniform green or green to black coloured potsherds are indicative of reducing firing conditions.

Under the polarized light microscope, sherds from all sites display a similar and quite homogenous distribution of their components (Fig. 5). Numerous samples display a bimodal grain size distribution with larger fragments of quartz, carbonate, feldspar or iron-titan-oxide of 0.1 to 0.5 mm in size. These relicts of raw materials are set in a very fine-grained to vitric matrix that is formed by quartz, feldspar, clinopyroxene, iron-titanium-oxide, and glass phase. This is mainly the case for Ubaid samples (Fig. 5d). In contrast, most of the Halaf sherds show a predominance of polymodal or serial grain-sized distributions without significant maxima, which leads to the impression that less care was given in the selection and preparation of the clay sources. Porosity is represented by sub-millimetre-sized voids, channels, and, especially in the case of potsherds of the Ubaid period, elongated pores of up to 3 mm in length, suggesting additions of organic chaff (Fig. 5h, j an l). Such relicts of organic materials are found only sporadically in older samples, for example, in one fragment from the *altmonochrome* stage at Tell Halaf (Fig. 5c) or in one sample from Khirbet Hagg Badran (Fig. 5i). However, their pore size is much smaller (max. 1 mm in length).

The spatial arrangement of mineral fragments, pores and relicts of organic substances is mostly irregular (Fig. 5a, c, d): the subparallel orientation of the mineral fragments (Fig 5c) or elongated cavities observed (Fig. 5j and l) is rare. The analysed sherds from the different sites show a variable porosity mostly < 10 vol.%, but in the case of the organic tempered Ubaid pottery as much as 28 vol.% was reached.

High resolution examinations with scanning electron microscopy and electron microprobe analysis document that during the firing process Al-Ca-Mg-rich clinopyroxene (fassaite) and gehlenite are generated in the fine grained matrix of the burnt sherds. Coarse feldspar relicts of the raw materials are often rich in potassium (K-feldspar), whereas in the new matrix, newly formed microcrystalline feldspar has a more calcium-rich composition (anorthite). Relicts of calcite grains are fine grained and re-crystallised, showing numerous fractures, pointing to the transformation of calcite into CaO during firing. Locally, calcite is surrounded by a narrow rim of a Ca-Si-phase, presumably wollastonite. These newly formed microcrystallites are surrounded by a porous Si-Al-Fe-Mg-Ca-rich glass phase, *i.e.* crystallised melt.

Quantitative phase analyses (*i.e.* Rietveld analysis) revealed a strongly heterogeneous composition of the sherds on an inter-site as well as on an intra-site level (*cf.* Drüppel 2015, 452 fig. 199). With the exception of one carbonate-rich Halaf sample from Agila-South (WHS 5-154), quartz (5–41%) and feldspar (11–39%) are the main constituents of all sherds. Alongside clinopyroxene (up to 53%), calcite (up to 37%) and gehlenite (up to 13%) are minor constituents. Accessory minerals are iron-titanium-oxides, and analcime, amphibole, or sanidine are rare. Eight of the 30 samples contain smaller portions of the original clay minerals (up to 8% illite) and iron-hydroxide (up to 1% goethite). These phases indicate that marl-clay was used as the main clay source.

In light of the existing phases, this heterogeneity can be mainly explained as due to differences in the composition of the clay sources. The simplified ternary diagram (Fig. 6) shows that the quartz-rich samples from Tell Halaf and Mishrife (WHS 21) range mainly in one field, bordered by tie-lines of quartz-diopside-anorthite. Sherds from Tell Tawila and other sites in the Tell Chuera region, with their higher calcium-magnesium contents, mainly fall into the stability field of diopside-anorthite-gehlenite. The latter samples indeed contain higher amounts of clinopyroxene and/or feldspar (anorthite) and, at the same time, lower contents of quartz. In contrast, modal amounts of gehlenite in different samples cannot be correlated with their chemical composition. For example, no gehlenite could be determined in sherds from Agila-South, despite their calcium-magnesium-rich composition, but they contain higher amounts of newly formed clinopyroxene. The same holds true for one sample from Khirbet Hagg Badran (sample WHS 15-156 – an Ubaid sample). This observation suggests that the firing conditions also played an important role for the resulting phase assemblage and should not be neglected.

The firing temperature can be mainly deduced from the minerals formed during the burning of the sherds. Larger fragments of calcite are heavily decomposed, re-crystallised and transected by microfractures, indicating that calcite was decomposed at temperatures of ca. 830–870°C into calcium oxide (lime = CaO) (*cf.* Boynton 1980). This transformation is interlinked with a decrease in volume and may lead to the formation of fractures or porosity in the pottery. During cooling, calcite can be newly formed out of calcium-oxide through re-hydration and re-carbonisation. The new formation of anorthite, gehlenite and clinopyroxene during the firing process, which can be found in the fine-grained to vitric matrix of most of the samples from different sites (the only exception is Agila-South), is remarkable. These phases are known from other ceramic products of lime-rich clays, in which gehlenite and anorthite are formed by calcite, quartz and the clay minerals (illite/muscovite) of the raw materials during firing. The newly formed clinopyroxene is presumably a result of the transformation of Mg-rich carbonates (f.e. dolomite) and/or reaction of Mg-silicates with quartz during the firing process, whereas wollastonite originates from the reaction of calcite and quartz.

Examinations of comparable ceramics (Cultrone *et al.* 2001) have demonstrated that wollastonite and gehlenite crystallise at temperatures roughly higher than 800°C, while the crytallisation of clinopyroxene and anorthite starts at only slightly higher temperatures around 900°C. The highest firing temperature, about 1000°C, is indicated in one early sample from Tell Halaf (TH 18) by the occurrence of sanidine, which was presumably transformed out of clay minerals or muscovite. Interestingly, this sample (TH 18, see Fig.3 and Fig. 4) is one example from the old excavations that was correctly described by H. Schmidt as a local imitation at Tell Halaf with Samarra influence (*cf.* Schmidt 1943 in von Oppenheim, 67 Taf. XC, 7 = Abb. 57).

The preservation of non-decomposed feldspar and illite as well as the absence of crystallised melted mass (glass) in some of the samples indicate that the firing temperature could not have been higher than 1000°C.

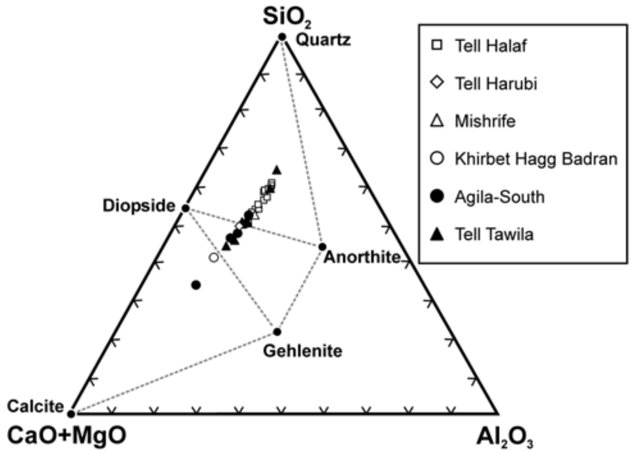


Figure 6. Chemical composition of Halaf and Ubaid sherds from different sites in northeastern Syria with their main phases, shown in a ternary SiO_2-CaO+MgO-Al_2O_3-diagram.

Generally it must be noted that the above mentioned transforming temperatures according to Cultrone *et al.* (2001) were calculated under oxidising conditions. Experiments in reducing systems document that, under such conditions, the respective reactions start at higher absolute temperatures (ca. 50–100°C higher; Peters/Jenni 1973).

The existing phases for the majority of the samples from different sites, fired under oxidising conditions, suggest that relatively consistent and homogenous firing temperatures of about 900°C were maintained; presumably higher temperatures up to ca. 1000° C were reached for a short time.

Clinopyroxene- and glass-rich and at the same time gehlenite-free samples from Agila-South and Khirbet Hagg Badran presumably document firing temperatures of more than 900°C: under these conditions, more clinopyroxene crystallises while the amount of gehlenite decreases (Cultrone *et al.* 2001).

In the case of the oxidised fired samples from Tell Halaf (TH 23 = Halaf IIb, TH 26 = Halaf IIb/HUT and TH 27 = *altmonochrom*; *cf.* Fig. 3) slightly lower firing temperatures below 800°C were reached. Under such conditions the sedimentary source minerals like for example the clay minerals remain partly preserved.

In general, the variations in the phases and firing temperatures of the analysed sherds from different sites and within the local groups lead to the conclusion that there was a local production of these ceramics, but with strong variations concerning the care in preparing the clay sources and the firing conditions. (Fig. 6).

GEOCHEMICAL X-RAY FLUORESCENCE ANALYSIS

All 123 samples were firstly analysed with a portable energy-dispersive X-ray-analyser (Type Xl3t 900S GOLDD = Geometrical Optimized Large Area Drift Detector; for a detailed report see Helfert 2015 with addendum 4). As different case studies have shown, the new generation of such instruments are suitable for their enhanced detector to make examinations of pottery (*cf.* Böhme/Helfert 2010, 13 ff.; Helfert 2011, 325 f. or Helfert *et al.* 2011). Unlike older models, proof of the light elements magnesium (Mg), aluminium (Al), silicium (Si), phosphor (P) and sulphur (S) are an important factor for the use of this method in archaeology, given that silicon and aluminium are especially essential for the characterisation of pottery. As a precondition for the use of portable energy-dispersive X-ray fluorescence analysis (pXRFA), the instrument needs to be finely calibrated and the parameters must be harmonised with the pottery matrix (Böhme/Helfert 2010, 18; Helfert *et al.* 2011, 6 f.). Through measurements of reference samples with known chemical composition, systematic errors can be detected and corrected. A selection of 140 pottery samples from a Roman context in Groß-Gerau (Germany), whose chemical composition had been analysed beforehand using another X-ray analysis series (WD-RFA; for the method see Helfert 2010, 247 ff.), was used for the fine calibration in the present analysis.

With the high agreement between both measurement procedures, the above mentioned X-ray analyser was able to measure nine main elements and thirteen trace elements. In general, the spectrum was broadened into 25 measured elements. For the main elements, the data are given in percentage by weight of their oxide, and for

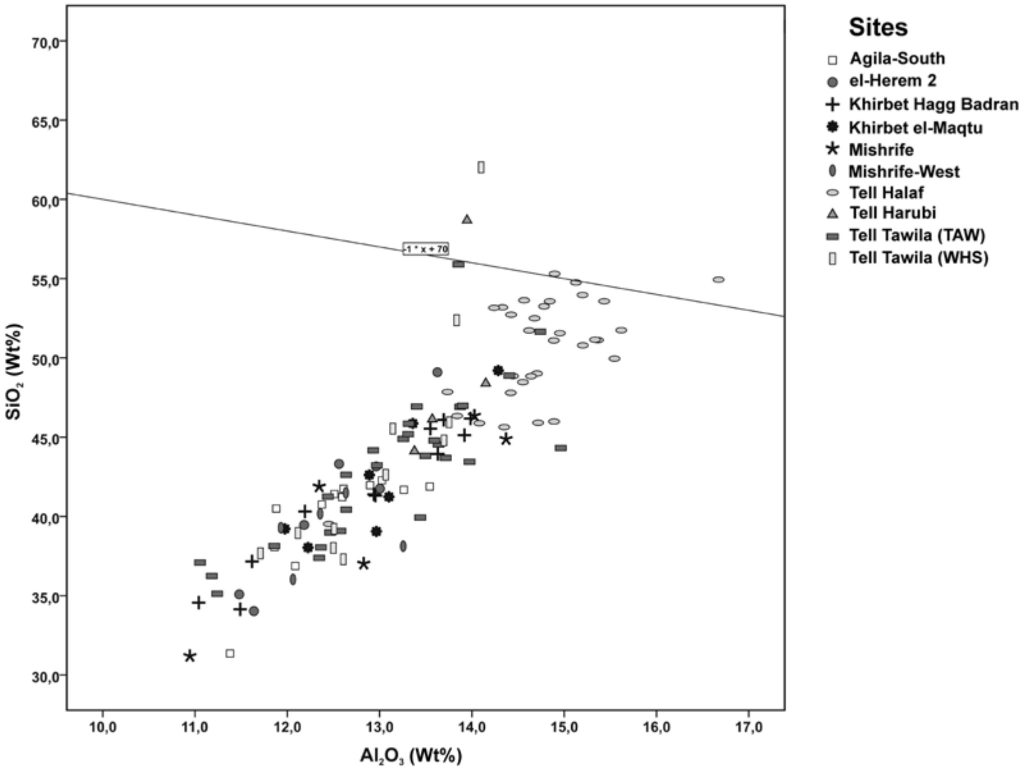


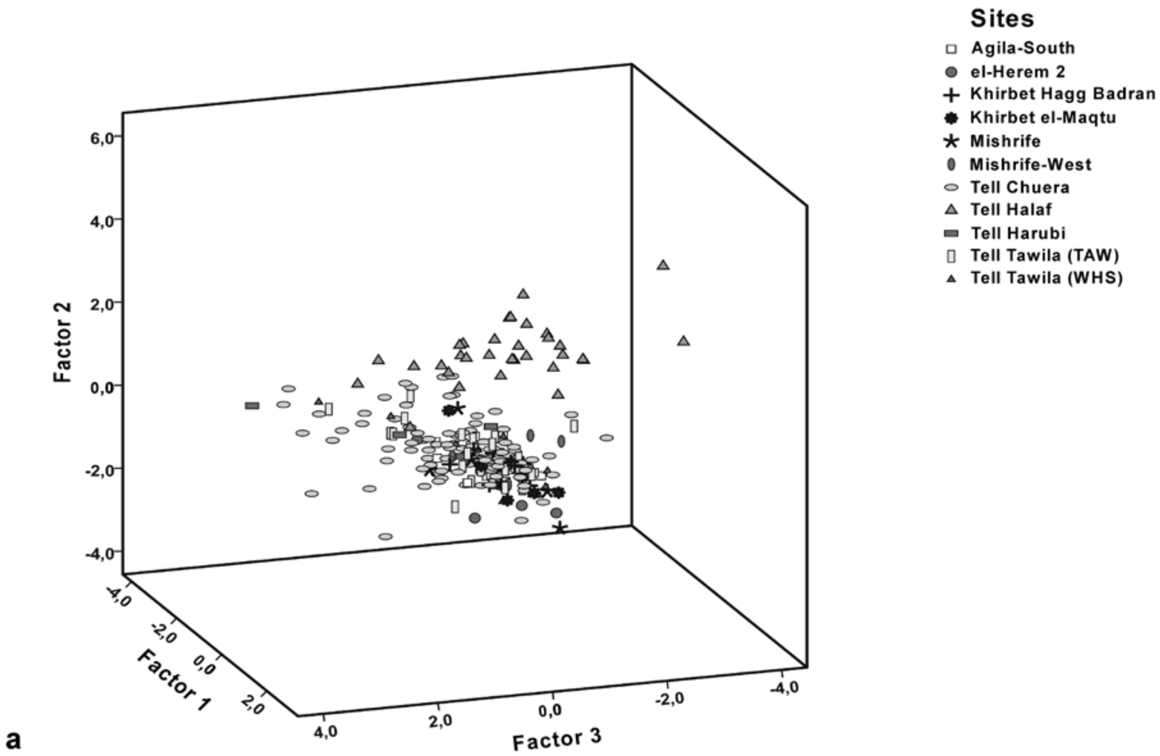
Figure 7. Scatter diagram of all samples showing SiO_2 (wt%) against Al_2O_3 (wt%), designated according to sites.

the trace elements in parts per million (*cf.* Helfert 2015 with addendum 4).

Concerning the question of clay preparation, several pottery studies could show that, through the levigation of the clay – whether this took place in pits or basins – the resulting clay mass, if we look for the content of silicon against aluminium, will be ordered on a correlation line (*cf.* Schneider 1988, 305 f.; Helfert 2010, 149 ff.), resulting in the reduction of sand (geochemical represented through SiO_2) and leading to an increase of clay (geochemically represented by Al_2O_3). Through this effect, bivariate element plots show characteristic curves with very small variance among single measurements ordered along a line. After a standardisation of the main elements to 100 percent, this line is (in an ideal case) an ascending slope with a gradient of -1. In the case that such correlation lines exist in the measurements, a statement can be made as to whether and how intensive levigation (or under dry conditions preparation through sieving) took place, and – based on the variance of the measurements – also a statement on how carefully such a levigation process was executed.

Similar to the mineralogical results of 30 selected sherds (see above), Figure. 7 also show that all 123 samples from all nine sites give no clear indication for the levigation of the clay. It can be further assumed, in view of the great variance in measurements, that in all sites no special care took place regarding the preparation of the clay. At the same time, it is recognisable that over the long time scale of the sites, mainly spanning the Halaf and Ubaid periods, but also reaching at maximum from Pre-Halaf to the Late Chalcolithic periods, similar clay sources were used in the nine sites. By trend, the low percentages by weight of SiO_2 can be seen as indicative of no tempering at all or at most only sporadic tempering, here excluding chaff temper in late Ubaid samples. Higher quartz (SiO_2) concentrations in the samples from Tell Halaf may be seen as a means of light mineral temper (Fig. 7).

Bivariate scatter diagrams and principle component analysis (PCA) were used concerning the question of local production and exchange between the analysed sites (*cf.* Ramminger/Helfert/Mecking 2010, 59 ff. for the description of the procedure) (Fig. 8). The three-dimensional diagram with the first three calculated parameters of the main component analysis (Fig. 8a) shows at first slight differences in the geochemical composition of the individual sites. Individual samples from Tell Tawila and Tell Harubi (WHS 19) are slightly separated from the dense scatter plot. Also, the main samples from Tell Halaf are distinguished in that scatter plot. This feature can be interpreted in geographic terms, according to which Tell Halaf is located 60 km northeast of the Tell Chuera region and is also separated by a watershed.



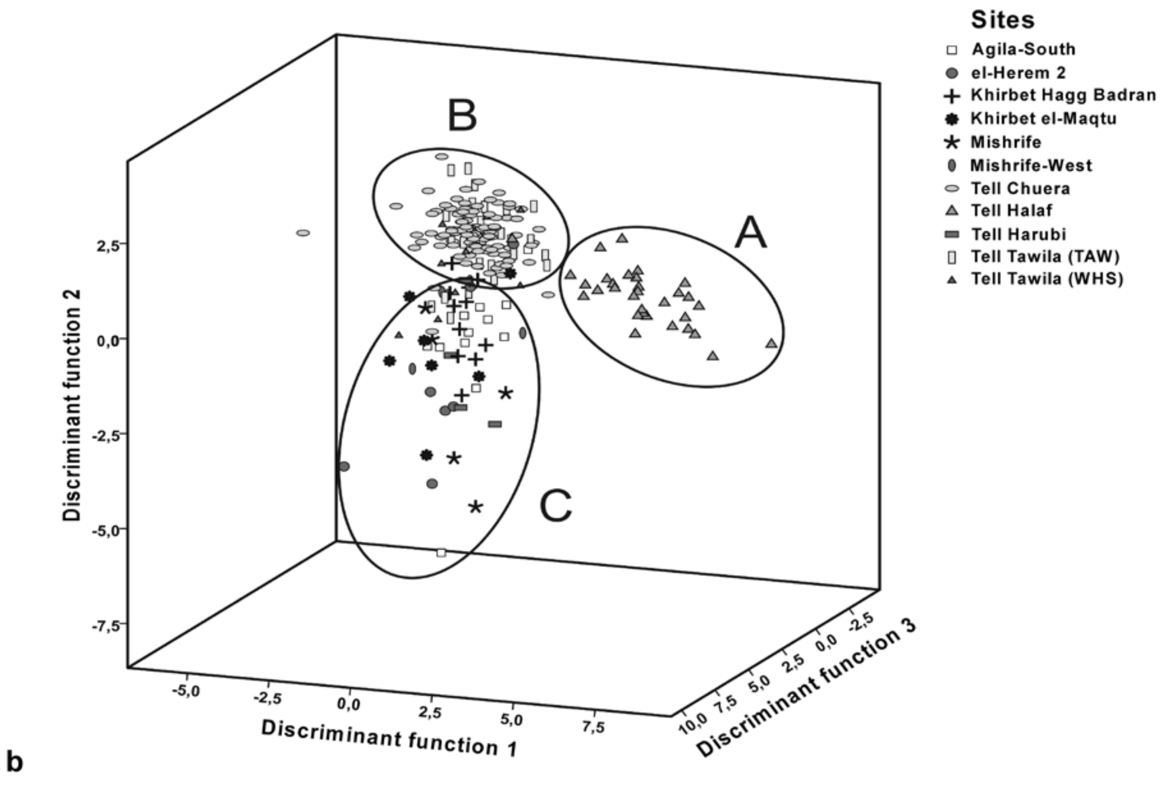


Figure 8. a) Position of all samples in a three-dimensional drawing after the three first factors of a principal component analysis (PCA), designated according to sites.

b) Position of all samples in a three-dimensional drawing after the first three functions of a canonical discriminant analysis (CDA), designated according to sites.

Therefore, different conditions of sedimentation and decomposition of the used clay sources seem to be responsible for these slight differences, under the premise that clay was not transported over greater distances.

Assuming that the analysed Halaf and Ubaid sherds were produced in a subsistence economy, mainly at each site, as is also indicated by wasters from Tell Halaf and Tell Tawila (*cf.* Becker 2015, 97 and 199), it is possible to undertake a canonical discriminant analysis (CDA) with the data on an inter-site level. In doing so, the homogeneity in the individual groups is checked and also the question as to whether the sites can be distinguished from each other (Fig. 8b). The analysis shows at first that each group is very consistent in itself, with some runaway values. Three clusters can be recognised in the three-dimensional diagram of the first three discriminant functions. These clusters comprise (A) samples from Tell Halaf, (B) pottery from Tell Tawila and – as a reference – Tell Chuera, and (C) other sites on the eastern part of the Wadi Hamar survey, *i.e.* the Tell Chuera region. A reason for this phenomenon could be slight differences in the sedimentation of the clay in the different wadi systems. Tell Tawila and Tell Chuera, for example, lie along the same Wadi Chuera, so that in this case it can be assumed that the quite similar chemical composition is based mainly on similar sedimentation processes along that wadi. Solely sites in the eastern part of the Tell Chuera region, group C, show a greater variance, but perhaps this is the result of their location on other wadis.

DISCUSSION

Halaf painted fine ware dominates the spectrum of Late Neolithic fabrics at Tell Halaf and Tell Tawila with ca. 80 % (Becker *et al.* 2007, 236 f. Fig. 18; Becker 2012, 33; 2015, 96 and 293), and is macroscopically characterised at first glance by quite a homogeneous appearance. The Halaf painted fine ware is often described as having been made of well levigated clay, mostly free of rough components from the original clay source, containing some only in minor quantities in small fractions (for example quartz, often > 0.5 mm), and having been fired consistently in an oxidising atmosphere (Rye 1981, 36 f.; Noll 1991, 235 and 237 f.; see also for example Becker 2007, 29). The fine clay matrix is quite visible along the break of such sherds. However, some rough pieces of lime together with other minerals were found in the core as well as on the surface, which had the negative capacity of cracking the surface during firing (*cf.* Rye 1981, 36 f.; Le Mière 1989; Noll 1991, 235 and 237 f.; Clop/Alvarez/Hatert 2004; Nieuwenhuyse 2007, 92).

Thus, it may be questioned whether the clay was really levigated, or whether the fine matrix of the Halaf painted fine ware should be seen rather as a clear selection of finer clay sources during the Halaf period (*cf.* the discussion by Nieuwenhuyse 2007, 92). T. E. Davidson (Davidson 1977, 28) already described mineral inclusions in the case of Halaf fine ware, which occurred naturally in the clay source used at that time by the Arpachiyah potters.

Our mineralogical/petrographical and geochemical analyses for Tell Halaf and Tell Tawila as well as other sites in the Tell Chuera region indicate through their variances in grain-size distribution and different inclusions that varying care was given in preparing the clay, depending more or less on the persons involved in the clay preparation and, thus, negates an intentional levigation process (*cf.* in contrast Spataro/Fletcher 2010, 108, who argue that levigation probably took place).

Similarly, examinations in Tell Amarna (Clop/Alvarez/Hatert 2004), for example, suggest that an intentional selection of finer clay sources was performed, without any necessary further treatment of the clay, to produce the often predominant fine ware fabrics.

Regarding Halafian coarse wares, different and coarser clay sources could have simply been selected. However, in these cases it is clear that such clay sources were tempered with rough sand minerals and/or partly with chaff. Specifically, the mineral temper had the positive feature of thermal conductivity and resistance to temperature changes, and thus functionally lent itself well as kitchen ware (*cf.* Rye 1981, 27; Rice 1987, 229; Le Mière/Picon 1994, 67). Similar tempering of coarse kitchen wares – including local and regional variations – can also be observed at several other Halaf sites, for example at Shams ed-Din or Cavi Tarlası (Gustavson-Gaube 1981, 73–76; von Wickede/Herbordt 1988, 20 f.).

The exchange of ceramic products is ultimately an important aspect, since it significantly determines discussions about areas with regard to regional and inter-regional networks, communication, forms of social organization and specialization.

As already in the 7th millennium cal. B.C. with the Proto Hassuna and Archaic Hassuna stages, and also in the earlier stages of the Ceramic Neolithic there was an intensive exchange of ceramic products, the traces of which could be determined through X-ray and cluster analyses. At least, some fine ceramic products in particular were transported over long distances (*cf.* Le Mière/Picon 1987; Bader *et al.* 1994).

With regard to the Late Neolithic Halaf culture of the 6th millennium cal. B.C, it was primarily the results of Neutron Activation Analyses (NAA) presented by T. E. Davidson / H. McKerrell some 40 years ago, which significantly determined the image of pottery production and exchanging ceramic products (Davidson/McKerrell 1976 and 1980; Davidson 1977, 349–395; Davidson 1981): The long series of analyses tried to geographically cover all areas of the Halaf pottery distribution, with a selection of sites from the northern Tigris region, the Khabur headwaters, sites along the Euphrates valley and finally sites from the Cilician-Levantine regions along the Mediterranean Sea: Arpachiyah, Tepe Gawra, Gird Banahilk, Tell Hassuna, Tell Brak, Chagar Bazar, Tell Aqab, Tell Halaf, Tell Mureybit, Shams ed-Din, Tell Kurdu, Sakaçagözü, Mersin and Ard Tlaili. Through their own field project, the excavations at Tell Aqab (Khabur triangle), as well as museum and university collections in Great Britain and the United States of America (for Arpachiyah and Tepe Tepe Gawra in the northern Tigris region), the detailed examination focused mainly on both aforementioned distribution areas in the eastern part of the Halaf culture. More survey locations particular to the Khabur triangle were included in the study, especially those in the vicinity of Tell Aqab and Chagar Bazar.

Methodically, specific sherds for each site were selected and compared with local clay sources (if available), and each sample was characterised by the measurements of eight trace elements.

Thereby, at first, samples that seemed to represent the typical type of fabrication for each site were collected; then, samples that did not fit into this pattern and were considered possible imports were chosen.

Comparison of pottery samples and soil samples using Neutron Activation Analysis produced a picture through which soil samples from the Wadi Dara, close to the east of Chagar Bazar, or along the Khabur close to Tell Halaf, could be correlated with the analysed pottery samples. It also further revealed that the wadi systems could be separated, and that the pottery was produced locally at both sites or at least in their immediate vicinity.

A different picture came to view through the comparison of the pottery samples from the six survey sites and local soil samples. Differences in the chemical composition led to the conclusion that a considerable amount of these Halaf samples were non-local in origin, but could be correlated with data from Chagar Bazar. During the late Halaf stage (Halaf IIb) Chagar Bazar seems to have exported mainly polychrome plates and saucers to at least five of the six survey sites. Hence, it was interpreted as a regional centre of the Halaf culture in the eastern part of the Khabur region, as assumed earlier by M. Mallowan (1936).

Further examinations by Davidson (1981) led to the conclusion that about 5–10% of the pottery from Tell Aqab was produced at Chagar Bazar. The exchange of polychrome painted plates and saucers during the late Halaf phase (Halaf IIb) also indicates that not the vessel contents, but the vessels themselves were exchange goods. In the case of Tell Aqab, this kind of exchange can be traced back to the Halaf Ib stage, during which a monochrome painted pot was transported from Chagar Bazar to Tell Aqab.

Similarly, according to these analyses, Tell Halaf and Tell Brak are interpreted as two further production centres of Halaf painted pottery in the Khabur triangle. These centres transferred painted vessels as special products to some smaller sites in their immediate vicinity and also exchange relations existed between these centres.

The comparison between analysed pottery from Arpachiyah and Tepe Gawra, 25 km to the northwest, allows to conclude, for the northern Tigris region, that about 30–40% of the painted vessels found in the deep sounding at Tepe Gawra were imported from Arpachiyah. These imports incorporate not only elaborate platters and saucers, well known from the *'burnt house'* in Arpachiyah (Mallowan/Rose 1935), but also simple painted examples. The fact that it was not the possible contents of the vessel that were was traded, but the vessel itself, is indicated by the formal restriction to flat, open vessel types and the absence of closed vessel types (pots or jars), which were transported from Arpachiyah to Tepe Gawra.

In summary, an extensive pottery exchange is implied, which essentially stimulated the homogenous appearance of the painted Halaf pottery, yet which did not show a great deal of regional stylistic variation, even though it covered a wide geographical distribution.

New evaluations of the original data with updated statistical methods have led in recent years to great doubt about such interpretations, the role and the intensity of pottery exchange in the Late Neolithic Halaf period. In sum, this re-evaluation does not contradict the theory that ceramics were exchanged, but instead concludes that the earlier NAA data do not support the specific model proposed by Davidson and McKerrell (Galbraith/Roaf 2001; *cf.* also Akkermans/Schwartz 2003, 138; Nieuwenhuyse 2010, 98; Spataro/Fletcher 2010, 93 f.).

New data from sites like Domuztepe, Tell Halaf, Chagar Bazar and Arpachiyah were recently published and studied in thin sections, and some of them were also analysed with energy dispersive X-ray analysis (SEM-EDX) similar to our own analysis methods. Through the thin sections, several different fabrics were identified at each site, showing the use of different clay sources and a similar formula for producing the fine ware. Chemical analyses show that the potters at Domuztepe and Tell Halaf used distinct clay sources for their pottery production. In contrast, chemical and mineralogical similarities were identified in the fine ware painted ceramics from

Chagar Bazar and Arpachiyah, indicating possible exchange networks of fine ware (Spataro/Fletcher 2010).

Concerning the role and intensity of pottery exchange, our results are in contrast to the above discussed studies. At least it must be stated in the case of the analysed samples from Tell Halaf and Tell Tawila that there is no clear indication of ceramic exchange. Solely one Halaf sherd sample, interestingly from Tell Halaf (TH 2), can be better assigned through its chemical signature to samples from the Tell Tawila/Wadi Hamar region; however, further examinations are necessary in this case to exclude an error value.

Concerning the homogenous group of samples from Tell Halaf, including some pieces made in the Samarra style, it is noteworthy that also at Tell Sabi Abyad no distinction was observed between the painted Halaf and Samarra-like pottery; both seem to have been locally manufactured at Tell Sabi Abyad (Le Mière 1989, 234). One might argue that the lack of evidence for exchange in the samples from Tell Halaf and Tell Tawila can be ascribed to the absence of special samples from Tell Tawila and the Tell Chuera region, *i.e.* the absence of sporadic pieces decorated with polychrome painting and/or plastic decoration among the selected samples, which might have been possible imports.

However, the intensity of pottery exchange during the Late Neolithic should also be questioned as stated according to Davidson/McKerrell in the case of Arpachiyah and Tepe Gawra, when they calculated that such an exchange could reach a range of 30–40 %. If correct, such an extensive exchange would mean that besides polychrome vessels, whose amount never rises above 5 % (Davidson 1977, 148 for Tell Aqab [< 5 %], or Becker 2012, 33 for Tell Halaf [< 3 %]; *cf.* Nieuwenhuyse 2000, 167), also monochrome painted vessels were transported to a considerable extent. Following this assumption, it would be quite expectable that the one or the other monochrome painted sample from Tell Chuera region was a proven product from Tell Halaf. However, as mentioned above, this was not the case.

CONCLUSION

With regard to the possible preparation of the clay, our mineralogical-petrographic and X-ray analysis brought forth similar results, according to which no special care was taken in conditioning the clay. This is indicated by the absence of indicators for the levigation of the original clay and the predominant lack of intentionally added mineral temper (excluded here are the mineral-tempered cooking pots of the Halaf period and the characteristic chaff-tempered, late Ubaid pottery). We interpret the variances in the clay matrix and the grain-size distribution as follows: during the Late Neolithic, finer clay sources were intentionally selected in earlier times and this specific clay was part of a widely shared formula used in the production of pottery vessels. Thereby, an additional conditioning of the clay by means of temper, as used for fine ware ceramics, could often be omitted.

The variances among samples on an intra-site and an inter-site level are further indicative of a primarily household-based pottery production, in which different groups of families participated. However, the analysed data clearly demonstrates that it is possible, especially on the basis of chemical signatures, to differentiate between various regional groups and some local groups, a differentiation that can presumably be correlated with the geological formation of the different wadi systems.

Such a homogeneous group is represented in the analysed samples of fine ware pottery from Tell Halaf, which is in itself very consistent for the Halaf as well as for the Ubaid period samples. The fact that it also comprises one singular example displaying Samarran influence does not necessarily contradict the thesis of Davidson about the exchange of ceramic products, especially since no comparative samples from adjacent sites in the area around Tell Halaf could be included in the study. Analysis of the singular Samarra sherd just indicates that this fragment, like others designated by H. Schmidt as local imitations, should also be interpreted as a further example of a local imitation in Samarra style, executed at Tell Halaf.

Concerning a possible exchange of pottery between Tell Halaf and Tell Tawila, that is, between two neighbouring regions, the results based on analysed samples are, nonetheless, clearly negative, and simply show that at least the selected samples are not evidence for such exchange relationships. However, it should be taken into account that for Tell Tawila and the Wadi Hamar region, no special potsherds could be incorporated in the sample selection.

Nevertheless, it may be assumed that in the late stage of the Halaf culture (Halaf IIb), the production of polychrome painted pottery, which is just a very small part of the pottery assemblages, was a special production, carried out by specialists who possessed the knowledge about controlling the firing atmosphere.

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BIBLIOGRAPHY

AKKERMANS, P.M.M.G. 1993, Villages in the Steppe. Late Neolithic Settlement in the Balikh Valley, Northern Syria. Ann Arbor: International Monographs in Prehistory (Archaeological Series 5).

AKKERMANS, P.M.M.G., SCHWARTZ, G.M. 2003, The Archaeology of Syria: From Complex Hunter-Gatherers to Early Urban Societies (c. 16,0000–300 BC), Cambridge Cambridge University Press, Cambridge World Archaeology.

BADER, N.O., BASHILOV, V.A., LE MIERE, M., PICON, M., 1994, Productions locales et importations de céramique dans le Djebel Sinjar au VIe millénaire, Paléorient 20, 1, 61–68.

BECKER, J. 2007, Nevali Çori: Keramik und Kleinfunde der Halaf- und Frühbronzezeit (with a contribution by L. Herling), Mainz: Zabern Verlag, Archaeologica Euphratica; 4.

BECKER, J. 2009, Untersuchung der prähistorischen Siedlung, in: Bagdo, A.M.H., Martin, L. Novák, M., Orthmann, W. (eds.) Ausgrabungen auf dem Tell Halaf in Nordost-Syrien. Vorbericht über die erste und zweite syrisch-deutsche Grabungskampagne auf dem Tell Halaf (Teil I), Wiesbaden, Harrassowitz Verlag, Vorderasiatische Forschungen der Max Freiherr von Oppenheim-Stiftung 3, I.

BECKER, J. 2011: Frühe Siedler am Tell Halaf – Zur Bedeutung der Halaf-Kultur, in: N. Cholidis, N. / Martin, L. (eds.) Die geretteten Götter aus dem Palast vom Tell Halaf. Begleitbuch zur Sonderausstellung des Vorderasiatischen Museums "Die geretteten Götter aus dem Palast vom Tell Halaf", vom 28.1–14.8.2011 im Pergamonmuseum, Regensburg: Schnell & Steiner, 345–351.

BECKER, J. 2012, Die Ausgrabungen in den prähistorischen Schichten, in: Bagdo, A.M.H., Martin, L., Novák, M., Orthmann, W. (eds.) Ausgrabungen auf dem Tell Halaf 2008 bis 2010. Vorbericht über die dritte bis fünfte syrisch-deutsche Grabungskampagne auf dem Tell Halaf (Teil II), Wiesbaden, Harrassowitz Verlag, Vorderasiatische Forschungen der Max Freiherr von Oppenheim-Stiftung 3, II.

BECKER, J. 2013a, Tell Halaf – Die prähistorischen Schichten, in: Bonatz, D., Martin, L. (ed.) 100 Jahre archäologische Feldforschungen in Nordost-Syrien – eine Bilanz. Internationales Symposium des Instituts für Vorderasiatische Archäologie der Freien Universität Berlin und des Vorderasiatischen Museums der Staatlichen Museen zu Berlin vom 21. Juli bis 23. Juli 2011 im Pergamonmuseum, Wiesbaden, Harrossowitz Verlag, 45–64.

BECKER, J. 2013b, Tell Halaf: New Results on the Late Neolithic Period in Northeastern Syria in Nieuwenhuyse, O.P. et al. (eds.), Interpreting the Late Neolithic of Upper Mesopotamia, Turnhout, Brepols, Papers on Archaeology of the Leiden Museum of Antiquities (= Palma); 9, 455–466.

BECKER, J. 2015, Tell Tawīla, Tell Ḥalaf und Wādī Ḥamar: Ḥalaf- und ʻObēd-Zeit in Nordost-Syrien. Regionale Entwicklungen, Gemeinsamkeiten und Unterschiede, Berlin, ex oriente, bibliotheca neolithica Asiae meridionalis et occidentalis.

BECKER, J., HELMS, T., POSSELT, M., VILA, E. 2007, Ausgrabungen in Tell Tawila, Nordost-Syrien (unter Mitarbeit von P. Aytaç, J. Eckhardt, J. Malo), Mitteilungen der Deutschen Orient-Gesellschaft 139, 213–268.

BÖHME, D., HELFERT, M. 2010 Herkunftsbestimmung von römischer Keramik mittels portabler energiedispersiver Röntgenfluoreszenzanalyse (P-ED-RFA) – Erste Ergebnisse einer anwendungsbezogenen Teststudie, in: B. Ramminger / O. Stilborg (eds.), Naturwissenschaftliche Analysen vor- und frühgeschichtlicher Keramik I: Methoden, Anwendungsbereiche, Auswertungsmöglichkeiten. Erster und zweiter internationaler Workshop für junge Wissenschaftlerinnen und Wissenschaftler in Hamburg am 9. Februar 2008 und 7. Februar 2009, Bonn: Habelt, Universitätforschungen Prähistorischer Archäologie; 176, 11–30.

BOYNTON, R.S. 1980, Chemistry and Technology of Lime and Limestone, New York: Wiley-Interscience, 2nd ed..

CAMPBELL, S. 1992, Culture, Chronology and Change in the Later Neolithic of North Mesopotamia, unpublished PhD thesis, Edinburgh.

CLOP, X., ALVAREZ, A., HATERT, FR. 2004, Characterization Study of Halaf Ceramic Production at Tell Amarna (Euphrates Valley, Syria), in Tunca, Ö. / Molist, M. (eds.) 2004, Tell Amarna (Syrie) I, La période de Halaf, (avec la colloboration de W. Cruells), Louvain, APHAO, 201–212.

CULTRONE, G., RODRIGUEZ-NAVARRO, C., SEBASTIAN, E., CAZALLA, O., DE LA TORRE, M.J., 2001 Carbonate and Silicate Phase Reactions during Ceramic Firing, European Journal of Mineralogy 13, 621–634.

DAVIDSON, T.E. 1977, Regional Variation in the Halaf Ceramic Tradition, unpublished PhD, Edinburgh: University of Edinburgh.

DAVIDSON, T.E. 1981, Pottery Manufacture and Trade at the Prehistoric Site of Tell Aqab, Syria, Journal of Field Archaeology, 8/1, 65–77.

DAVIDSON, T.E., MCKERRELL, H. 1976, Pottery Analysis and Halaf Period Trade in the Khabur Headwaters Region, Iraq 38/1, 45–56.

DAVIDSON, T.E., MCKERRELL, H. 1980, The Neutron Activation Analysis of Halaf and Ubaid Pottery from Tell Arpachiyah and Tepe Gawra, Iraq 42/2, 155–167.

DRÜPPEL, K. 2015, Mineralogische und petrographische Untersuchungen an Keramik-scherben der Ḥalaf- und ʻObēd-Zeit aus verschiedenen Fundorten Nordost-Syriens, in Becker, J., Tell Tawīla, Tell Ḥalaf und Wādī Ḥamar: Ḥalaf- und ʻObēd-Zeit in Nordost-Syrien, Regionale Entwicklungen, Gemeinsamkeiten und Unterschiede, Berlin, ex oriente, bibliotheca neolithica Asiae meridionalis et occidentalis, 452–458.

GALBRAITH, J., ROAF, M. 2001, Does the Neutron Activation Analysis of Halaf Pottery Provide Evidence of Trade? A Re-examination of Davidson and McKerrel's Investigation of Halaf Pottery from the Khabur Basin in Eastern Syria, LSE Department of Statistics Research Report, London, London School of Economics.

GUSTAVSON-GAUBE, C. 1981, Shams ed-din Tannira: The Halafian Pottery of Area A, Berytus 29, 9–182.

HELFERT, M. 2010, Groß-Gerau II: Die römischen Töpfereien von Groß-Gerau, „Auf Esch". Archäologische und archäometrische Untersuchungen zur Keramikproduktion im Kastellvicus, Bonn: Habelt, Frankfurter Archäologische Schriften 11.

HELFERT, M. 2011, Geochemische Untersuchungen von Terra Sigillata mit mutmaßlichem Produktionsort Trier, in: C. Moneta, Eine Trierer Sigillata-Reliefschüssel mit zwei Modelgraffiti des Perpetuus. Eine Studie zur Perpetuus-Primanus-Dignus-Gruppe, Jahrbuch des Römisch-Germansichen Zentralmuseums, Mainz (= JbRGZM), 55, 2 (2008), 325–330.

HELFERT, M. 2015, Bericht über die geochemischen Untersuchungen zu spätneolithischer/ chalkolithischer und bronzezeitlicher Keramik aus Nordost-Syrien, in J. Becker, J., Tell Tawīla, Tell Ḥalaf und Wādī Ḥamar: Ḥalaf- und ʻObēd-Zeit in Nordost-Syrien. Regionale Entwicklungen, Gemeinsamkeiten und Unterschiede, Berlin, ex oriente bibliotheca neolithica Asiae meridionalis et occidentalis, 443–451.

HELFERT, M., MECKING, O., LANG, F., VON KAENEL, H.-M. 2011, Neue Perspektiven für die Keramikanalytik. Zur Evaluation der portablen energiedispersiven Röntgenfluoreszenzanalyse (P-ED-RFA) als neues Verfahren für die geochemische Analyse von Keramik in der Archäologie. Frankfurter elektr. Rundschau Altkde. 14 (Frankfurt 2011) 1–30. http://www. fera-journal.eu.

HOLE, F. 2001, A Radiocarbon Chronolgy for the Middle Khabur, Syria, Iraq 63, 67–98.

LE MIÈRE, M. 1989, Clay Analysis of the Prehistoric Pottery: First Results, in Akkermans, P.M.M.G. (ed.) 1989, Excavations at Tell Sabi Abyad, Prehistoric Investigations in the Balikh Valley, Northern Syria, Oxford, BAR International Series, 468, 233–235.

LE MIÈRE, M., PICON, M. 1987, Productions locales et circulation des céramiques au VIe milléniere au Proche-Orient, Paléorient 13/2, 133–147.

LE MIÈRE, M., PICON, M. 1994, Early Neolithic Pots and Cooking, in Wartke, R.-B. (ed.), Handwerk und Technologie im Alten Orient. Ein Beitrag zur Geschichte der Technik im Altertum, Internationale Tagung Berlin 12.-15. März 1991, Mainz, 67–70.

MALLOWAN, M.E.L. 1936, The Excavations at Tell Chagar Bazar and an Archaeological Survey of the Habur Region 1934–1935, Iraq 3, 1–87.

MALLOWAN, M.E.L., ROSE, J.C. 1935, Excavations at Tall Arpachiyah, 1933, Iraq 2, 1–178.

MOOREY, P.R.S. 1999, Ancient Mesopotamian Materials and Industries. The Archaeo-logical Evidence, Winona Lake, Indiana: Eisenbrauns.

NIEUWENHUYSE, O.P. 2000, Halaf Settlement in the Khabur Headwaters, in Lyonnet, B. (ed.), Prospection archéologique du Haut-Khabur occidental (Syria dur N.E.), vol. I, Beirut, Bibliothèque Archéologique et Historique, 155, 151–260.

NIEUWENHUYSE, O.P. 2007, Plain and Painted Pottery, The Rise of Neolithic Ceramic Styles on the Syrian and Northern Mesopotamian Plain, Turnhout, Brepols, Papers on Archaeology of the Leiden Museum of Antiquities (= Palma); 3.

NIEUWENHUYSE, O.P. 2010, A Household affair? Pottery Production in the Burnt Village at Late Neolithic Tell Sabi Abyad, in Bolger, D, Maguire, L.C. (eds.) The Development of Pre-State-Communities in the ancient Near East, Studies in Honour of Edgar Peltenburg, Themes for the Ancient Near East, Oxford and Oakville, BANEA Publication Series; 2, 97–105.

NOLL, W. 1991, Alte Keramiken und ihre Pigmente. Studien zu Material und Technologie. Stuttgart, E. Schweizerbart'sche Verlagsbuchhandlung.

PETERS, T., JENNI, J.-P. 1973, Mineralogische Untersuchungen über das Brennverhalten von Ziegeltonen, Beiträge zur Geologie der Schweiz 50, 1–59.

RAMMINGER, B., HELFERT, M., MECKING, O. 2010, Zur Herkunftsbestimmung Bandkeramischer Gefäße: Das Beispiel Herxheim, in: B. Ramminger / O. Stilborg (eds.), Naturwissenschaftliche Analysen vor- und frühgeschichtlicher Keramik I: Methoden, Anwendungsbereiche, Auswertungsmöglichkeiten. Erster und zweiter internationaler Workshop für junge Wissenschaftlerinnen und Wissenschaftler in Hamburg am 9. Februar 2008 und 7. Februar 2009, Bonn: Habelt, Universitätsforschungen zur Prähistorischen Archäologie; 176, 51–74.

RICE, P.M. 1987, Pottery Analysis, A Sourcebook, Chicago: The University of Chicago Press.

RYE, O.S. 1981, Pottery Technology: Principles and Reconstruction, Washington: Taraxanum, Manuals in Archaeology; 4.

SCHNEIDER, G. 1988 Chemische Zusammensetzung römischer Keramik im Rhein-Main-Gebiet, in: V. Rupp, Wetterauer Ware – Eine römische Keramik im Rhein-Main-Gebiet, Regensburg, Schnell & Steiner, Schriften des Frankfurter Museums für Vor- und Frühgeschichte; 10, 303–327.

SPATARO, M. 2002, The First Farming Communities of the Adriatic: Pottery Production and Circulation in the Early and Middle Neolithic, Trieste, Edizioni Svevo, Società per la Preistoria e Protostoria della Regione Friuli-Venezia Giulia, Quaderno; 9.

SPATARO, M., FLETCHER, A. 2010: Centralisation or Regional Identity in the Halaf Period? Examining Interactions within Fine Painted Ware Production, Paléorient 36/2, 91–116.

VON OPPENHEIM, M. 1943, Tell Halaf I, Die prähistorischen Funde bearbeitet von Hubert Schmidt, Berlin, Walter de Gruyter.

VON WICKEDE, A., HERBORDT, S. 1988, Çavi Tarlası. Bericht über die Ausgrabungs-kampagnen 1983–1984, Istanbuler Mitteilungen 38, 5–35.