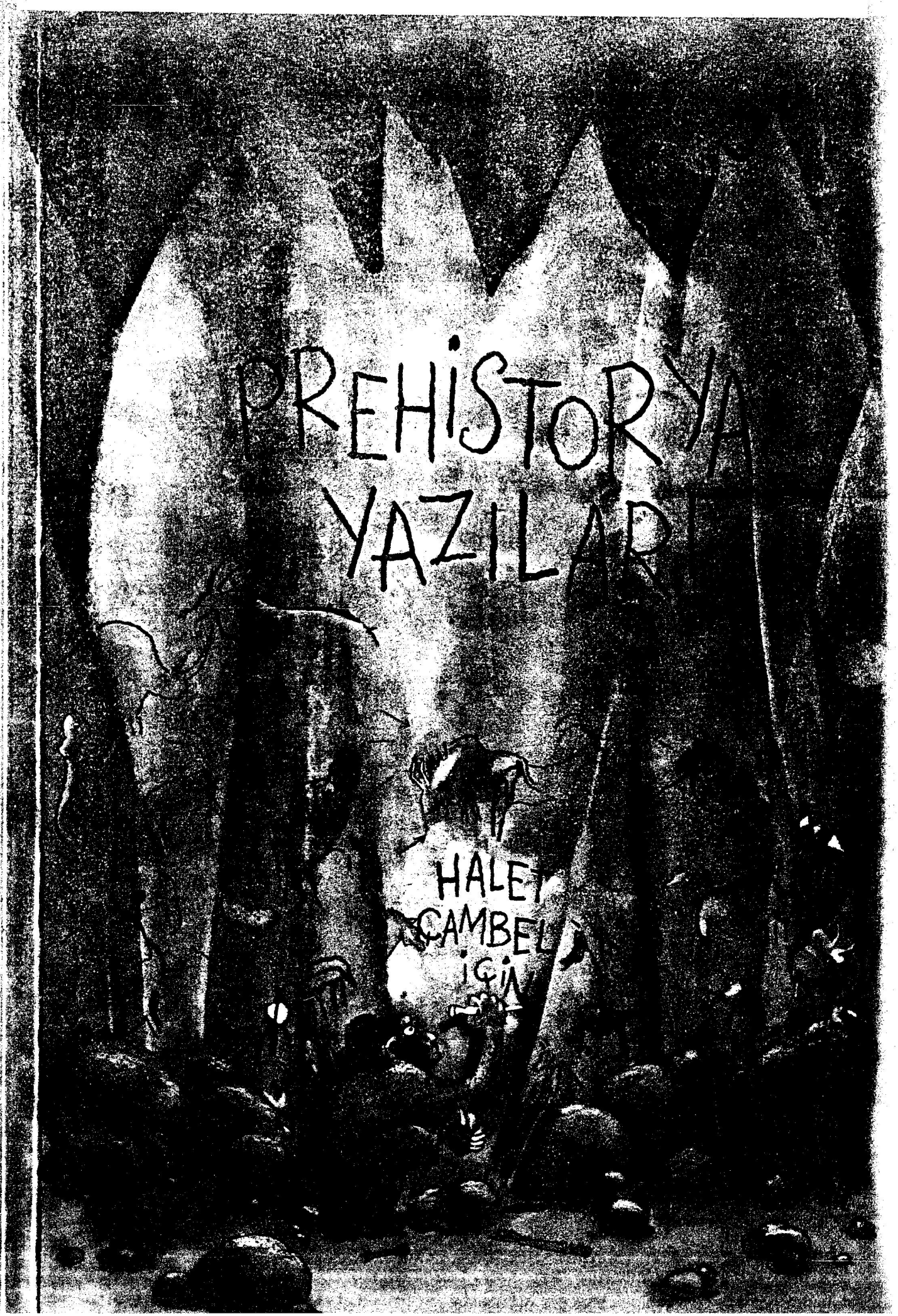
PREHİSTORYA
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READINGS IN PREHISTORY

Studies presented to Halet Çambel

İstanbul
1995

Early Copper Metallurgy at the Pre-Pottery Site of Aşıklı

Ufuk Esin

Özet

Son yıllarda, Orta Anadolu'daki çanak çömlek öncesi yerleşim yerlerinden Aşıklı Höyük'te gerçekleştirilen arkeolojik çalışmalar, bakır ve malakitin en eski kullanımı konusunda yeni verilerin elde edilmesine neden olmuştur. Döğülmüş bakır levhadan dört küçük örneğe ait metalografik, NAA, AAS ve Kurşun-İzotop analizlerine başlanmış ve bunların bazıları da sonuçlandırılmıştır. NAA, AAS ve metalografik analiz sonuçlarına göre Aşıklı'da doğal (nâbit) bakır soğuk çekiçleme ve tavlama ile işlenmiştir. Ayrıca doğal bakırın sağlandığı kaynağın, G-D Anadolu'daki çanak çömlek öncesi Çayönü'nde kullanılan bakırdan farklı olması ihtimali kuvvetlidir. Bu da, Anadolu'ya yerleşen ilk topluluklar tarafından bakırın tek bir yerden değil, birkaç farklı kaynaktan sağlandığını gösterir. Bu doğruysa, büyük olasılıkla, Anadolu ilk bakır madenciliğinin merkezi olarak kabul edilebilir.

Abstract

Recent excavations at the pre-pottery site of Aşıklı Höyük in Central Anatolia brought to light new evidence for the early use of copper and malachite. The metallographic, NAA, AAS and Lead-Isotope Analyses of four small samples made of hammered copper-sheet are being undertaken and some of them have been completed. According to the results obtained from the NAA, AAS and metallographic analyses, annealing and cold-working of native copper were used at Aşıklı. On the other hand, the source of the native copper exploited by the people of Aşıklı seems to be different than the copper source used at the aceramic site of Çayönü in South-East Anatolia. This suggests that there were numerous sources of copper exploited by the Early Anatolian settlers. Therefore one may assume that Anatolia can be considered as the home-land of Early Copper Metallurgy.

1. Introduction

The first attempts made by men to use metals for small utensils and jewellery such as beads, pendants, pins, awls or reamers, rolled small sheets, hooks and tablets made of copper are attested in the Near East, especially in Anatolia since the Aceramic Neolithic Period, almost nine thousand years ago (Esin 1976:210-213; Merpert and Munchaev 1993:241-248). Because of the discovery of copper finds and copper ore (malachite) in large amounts in the Pre-Pottery Neolithic phase at Çayönü from 1964 onwards by its excavators H.Çambel and R.J.Braidwood and after 1985 by A. and M. Özdoğan it was possible to undertake various archaeometallurgical studies with a new perspective to investigate the problems of "Early Metallurgy" in human technological and cultural history (Braidwood-Çambel 1982:11; Personal communication with A. Özdoğan in 1994).

Among many other problems to be solved in order to understand the manufacturing techniques involved at Çayönü there were some questions to be answered about the copper objects at the site :

One of them was to find out definitely if "Pyrotechnology" (annealing of copper) had been in use at Çayönü in that early period. The second question was to identify the kind of copper ores used at Çayönü and if possible to determine their provenance (Çambel and Braidwood 1983:157,165). Therefore various analyses of copper and malachite objects from Çayönü were made (Maddin, Stech, Muhly 1991).

The analyses especially made by R. Maddin resulted in the recognition that —besides the objects made of malachite— native copper had been used for the metal finds of Çayönü (ibid.375 ff.). Cold and hot working (annealing) have also been observed on some of the copper objects from Çayönü which have been analyzed by optical metallography where to identify native copper and whether it was worked in the annealing process the type of recrystallisations of "twin structures" in copper seems to play an important role (Maddin, Stech, Muhly 1991:379; idem. 1980:216)[1].

Only the determination of the provenance of native copper and malachite used at Çayönü is still in debate and in process. There is a possibility that the source of these ores was not at Ergani. A mine in the village of Kızıltarla near Çayönü discovered by Professors Ö. Öztunalı and G.A. Wagner during their surface survey for ancient mines in Eastern and South-Eastern Anatolia is another candidate for the provenance of the Çayönü copper (Maddin, Stech, Muhly 1991:378).

The excavations undertaken since 1989 at the Pre-Pottery site of Aşıklı brought to light in 1991 new evidence for the early use of copper and malachite, but this time in Central Anatolia (Esin 1993). In 1992 additional jewellery made of copper was found at the same

[1] Personal communication with Professor Emel Geçkinli in 1994. I'm very much indebted to her for the detailed information about "twin structures" in copper.

site. The continuous discovery of copper finds seems to make Aşıklı another center of Early Copper Metallurgy almost with the same problems to be discussed below which had to be faced at Çayönü.

In this respect this paper is dedicated to Prof. Dr. HALET ÇAMBEL, as one of the famous excavators of Çayönü, who is also a well-known, distinguished scholar because of the discovery and excavations of the Neo-Hittite Kingdom at Karatepe, up on the Taurus hills in Cilicia where she almost spent her whole life, in hope to make a small contribution to comparisons with the Early Metallurgy in South-Eastern Anatolia, because everybody close to her knows that she always seeks to have more detailed information in all research undertaken not only in Prehistory, but also in all fields of Applied Sciences for Archaeology.

2. Aşıklı and Its Copper Finds

Aşıklı lies 25 km South-East of the province of Aksaray, on a bank of the Melendiz River which runs through the famous Ihlara Valley, before it reaches the Kızılkaya Village, where the prehistoric mound is situated. The volcanic, Cappadocian landscape with tufa cones, andesite and granite rocks formed by the eruptions of Hasandağ which began during the Miocene, surrounds the vicinity of Aşıklı where the narrow Melendiz Valley is the only green spot (fig.1). Due to the same volcanic activities many obsidian sources are available in the neighborhood of Aşıklı which have been exploited by human communities for their implements and weapons since prehistoric times.

Because, in a few years the mound of Aşıklı will be partly flooded by the réservoire lake of Mamasın Dam, built on the Uluırmak on a branch of Melendiz River, salvage excavations are carried out at the site since 1989 by the Prehistory Department of the University of Istanbul (Esin et al. 1991; idem. 1994).

So far in the course of the excavations at Aşıklı, counted from top to bottom layer 2 with its 7 subphases, has been more extensively brought to light (figs. 1-2, 5). On the other hand to the south of the mound directly at the river side, beneath an alluvial accumulation of 1.5 m height, part of an early settlement has been discovered in 1993 which proved that one of the earliest occupations at Aşıklı was more extended and larger than previously assumed (Fig. 3). An almost homogeneous and so far unknown Pre-Pottery Neolithic culture has been discovered in the settlements of the subphases of layer 2 of Aşıklı founded by intensified hunters, gatherers and early farmers during the beginning of the Early Holocene. The analyses of the plant remains, as well as of the large amount of hunted animal bones, undertaken by Prof. van Zeist and by Dr. H. Buitenhuis from the *Biologisch-Archaeologisch Institute* at *Groningen* indicate that the beginning of early agriculture existed but the domestication of animals had not yet been started at Aşıklı. The subsistence economy was mainly based still on hunted animals.

According to the uncalibrated 46 ^{14}C assessments of which 41 have been completed by Dr. Ir. J. van der Pflicht at the *Centrum voor Isotopen Onderzoek* at the State University of Groningen, the Aşıklı culture can be dated to the tenth ninth milennium BP (figs. 11-12; Esin et al. 1991:125-126; idem.1993:181)[2].

The settlements in the subphases of layer 2 at Aşıklı have an unusual lay out: almost remining of a plan of a town. They consist of two large sections, one to the north, the other one to the south of a wide pebble street named "GA" (fig.5). The buildings are usually made of primitive mud-bricks without stone foundation walls and have one or more rooms (figs. 2, 5). They are used by the hunters of Aşıklı as houses. In most of the houses hearths are built in the corners of the walls. Two or three houses are placed together in small quarters which are separated from each-other by narrow paths or small court-yards (figs. 2,5). Although there are door-openings in partition walls between the rooms of the large houses, there is not a single entrance into the buildings from the outside (fig. 2).

On the other hand large spaces, sometimes pits, are left between the quarters for sharing the meat of the hunted animals among the occupants of the settlements. The inhabitants of the settlements used them also as rubbish places where the thrown garbage are then burnt (figs. 2, 5 [trenches 6-7 J-K, "JA"]).

Two buildings on the south-west of the large pebble street and another structure on the east side of the mound seem to have other functions than residential use. One of the buildings to the south of the street is square in plan and has stone foundation walls underneath its upper structure made of mud-bricks which were strongly destroyed. In each subphase the building has red painted floors and walls. From top to bottom in its third subphase the red floor is partly restored and only this renewed section of the floor has been painted in yellow (figs. 1, 5 [trench 3-4 P-R, building T]).

The second building is also square in plan but larger than the former. It is bordered on its northern side by a casemate-wall consisting of two walls parallel to each other leaving space in between for empty rooms (figs. 1,5 [trenches 3-4 N-O, building "HV"]; Esin 1994). Because of the differences in their architectural characteristics these buildings might have belonged to the rulers of the inhabitants. The building with the painted floor and walls could be used also for religious, ceremonial practices when compared to the temple of Nevali Çori (Hauptmann 1993:41 ff.).If these assumptions are correct they indicate a stratification in the community life at Aşıklı.

The last structure to the east of the mound is not yet completely excavated, but it seems to be monumental with its rounded stone wall and stone-paved floor (fig.4).

The main industry of Aşıklı is based on obsidian tools and weapons where the blades and scrapers are dominant.The blade industry of Aşıklı has so far no known parallel from other Pre-Pottery sites in Anatolia or in the Near East (Esin et al. 1991:133,145-149,170-174, pls.12-16). The next one in importance is the bone/horn industry (fig.6; ibid.134,168, pl.10). The

2 Former 5 radio-carbon dates from Aşıklı have been published by I. Todd (Todd 1980,149). For the large amount of additional radio-carbon dates mentioned above I am very much indebted to Prof. Dr. Bottema, to Dr. van der Pflicht and to Dr. H. Buitenhuis for their assistance and help in providing them.

ground and polished stone artefacts are not found in large amounts (fig.6; ibid.133,167,169, pl.11). There are also half-baked small clay objects and a terracotta figurine in conical shape (figs. 6-7; ibid.134,168).

The burial custom in layer 2 seems to be intramural. The deceased are buried in earthen pits under the floors of the rooms in mud-brick buildings (Esin et al. 1991:131-132,167, pl.9.1). Necklaces, bracelets made of beads are almost the only gifts left with the burials. The beads are usually made of semi-precious or of simple stones. Among them there are also beads made of small massive copper pieces or of rolled copper sheets and also probably of malachite which have been discovered with burials under the floors of rooms GM in trench 4-L and HB in trench 4-M discussed in detail in a previous paper (figs.5,8; Esin 1993; GDMM 1993,46/A 22).

In 1992 a burial of a young woman (AH.92-ISK.13) has been discovered in "hocker position" under the floor of room KE in trench 7-M who has been badly damaged (figs. 5,9). She wore on her head a diadem consisting of beads made of deer teeth and of rolled copper sheets (AH.92-105, fig. 10; GDMM 1993, 47/A 23).The dimensions of the 52 deer teeth range between 1.6-2.5 cm in length. 0.8-1.1 cm in width. Each tooth has been pierced through its flat upper part (fig.10).
On the other hand the dimensions of the 7 copper beads are ranging between 0.5-0.9 cm in length and 0.6-0.7 cm in diameter.
There were also broken or corroded pieces of copper beads or ores collected together with other beads from the burials in rooms GM, HB and also in KE (figs. 5,8-10; Esin 1993:181 ff. fig. 2, pls. 34-35; GDMM 1993.46-47/A 22-23). Some of those pieces are chosen as samples for the metallurgical investigations of which 3 elemental, 2 isotopic and 2 metallographic analyses are now available. They provide some valuable information for understanding the level of "early copper metallurgy" at Aşıklı and also for comparisons with the "copper metallurgy" of Çayönü.

3. Analyses of Copper and Copper Ore Samples of Aşıklı

The sample (AH.91-343/A) which has been found together with the massive copper bead (AH.91-343) in room HB and the other sample (AH.91-194 A) which has been discovered with the string of beads (AH.91-194) in room GM are analyzed by Prof. Dr. E. Pernicka at the Max-Planck Institute in Heidelberg using the neutron activation (NAA) method (cf.fig.5.8.13; Esin 1993:181,182,fig. 2, pls. 34.35). For the same samples lead-isotope analyses are completed by Prof. Dr. F. Begemann and by Dr. S. Schmitt-Strecker at the Max-Planck Institute in Mainz.
The atomic absorption (AAS) analysis of another sample (AH.92-105/A) which has been found together with the diadem (AH.92-105) of the young female burial (AH.92.ISK.13) in room KE has been undertaken by Prof. Dr. H. Özbal at the Boğaziçi University in Istanbul of which the

optical metallographic analysis has been provided by Prof. Dr. E. Geçkinli at the Technical Univesity of Istanbul (cf. fig. 5,8,10,13; GDMM 1993,47/23).
The last sample (AH.92-105/B) which has been unearthed also with the diadem (AH.92-105) in room KE has been analyzed by Dr. Ünsal Yalçın at the *Deutsches Bergbaumuseum, Institut für Archaeometallurgie* in *Bochum*, using again optical metallography (cf. fig. 5,8,10; GDMM 1993,47/23)[3].
According to the compositions of trace elements in two samples analyzed by the NAA and AAS methods native copper has been used for some beads of Aşıklı, although the results of both methods are not comparable to each other (fig. 13, HDM 1800/AH.91-194/A and BU.93.206/AH.92-105/A). Because of the NAA analyses of the other sample Professor Pernicka considers that it has been not made of native copper but most probably of malachite (fig. 13, HDM 1799/AH.91-343/A)
The compositions of the trace elements of these three samples indicate that the sources for copper ore which have been exploited by the settlers of Aşıklı were not the same which have been used by the inhabitants of Çayönü (cf. fig. 13 with Maddin, Stech, Muhly 1991:376, table 1)

In this respect the results of the lead-isotope analyses of the samples of Aşıklı which have been analyzed also by NAA method could help probably more, when they will be evaluated by Prof. Begemann and by Dr. Schmitt-Strecker (fig. 13, HDM 1799/AH.91-343/A; HDM 1800/AH.91-194/A).
On the other hand the high percentages of the trace elements such as tin and arsenic in the native copper of Aşıklı which have been analyzed by the AAS technique are remarkable and remind one of the high arsenic content of the reamer or awl from Çayönü (fig. 13, BU.93.206/AH.92.105/A, cf. with Maddin, Stech. Muhly 1991:376, table 1,7015 [R]).
For identifying the manufacturing techniques and determining the kind of ore used at Aşıklı the same sample BU.93.206/AH.92.105/A has been analyzed by optical metallography (fig.13). According to Prof. Dr. E. Geçkinli it has been made of native copper and the recrystallisation of "twin structures" observed in the copper must be due to a secondary natural, geological formation process. According to her there is also no indication found so far for the hot-working of copper.
On the contrary, according to Dr. Ü. Yalçın the metallographic analysis of the sample TR-12/1/AH.92-105 B indicates that it has been also made of native copper and traces of hot hammering (annealing/pyrotechnology) have been observed and attested (Personal communication with Dr. Ü. Yalçın in June 12.1994).
If the results of both metallographic analyses of two samples discovered in the same find spot, are taken into consideration, it can be said that the inhabitants of Aşıklı knew how to anneal copper and that when they wanted they also produced rolled sheets of copper by hot or cold working.

3 I am very much indebted to Professors Dr. E. Pernicka, Dr. F Begemann, Dr.S.Schmitt-Strecker, as well as to Professors Hadi Özbal Emel Geçkinli and to Dr. Ünsal Yalçın for their kind help and courtesy in providing these analyses of Aşıklı and also for additional informations about the results of the analyses, of which only a part is published here.

Therefore "pyrotechnology —the knowledge of annealing native copper" must have been invented consciously, but independently by the communities living at Aşıklı and Çayönü during the Pre-Pottery Neolithic period. although the culture of Çayönü was based for certain extent on agriculture and the community of Aşıklı mainly on hunting.

4. Conclusions

According to the 5 metallurgical analyses undertaken for the copper samples of Aşıklı it can be considered tentatively that:

1. Native copper and malachite are used for the beads of Aşıklı (figs. 8,10,13),
2. The elemental compositions of the trace elements indicate that the provenance of the native copper and of malachite used at Aşıklı is not the same as the source of native copper or malachite implements and jewellery at Çayönü (fig. 13; Maddin, Stech, Muhly 1991:376, table 1),
3. The manufacturing techniques of rolled sheet beads of Aşıklı are varying, although they have been discovered all together in a closed assemblage (fig. 9,10,13, BU.93.206/AH.92.105/A, and TR-12 1/AH.92-105/B). One had been worked by hammering and annealed, the other one had been prepared only by cold working,
4. The recrystallisations of "twin structures" in native copper to identify "pyrotechnology" is important but it seems that more research is needed for clarification the differences between natural and annealed twin structures, because the same problem has been faced at Çayönü and now is confronted also at Aşıklı,
5. The exploitation of different copper sources, the use of native copper and the use of annealing for manufacturing small objects made of sheet copper, all indicate that the "Early Copper Metallurgy" was not restricted to one site. On the contrary, the knowledge of copper working was probably rather widespread in Anatolia as evidenced at Aşıklı and at Çayönü,
6. The "Early Copper Metallurgy" was not only an invention of an agrarian community which has been attested at Çayönü. But also there was a parallel technological process which had been developed in a culture based on hunting as it has been observed at Aşıklı.

These tentative conclusions in mind. it can be assumed that Anatolia most probably was the home-land of Early Metallurgy from the beginning of settled life during the tenth/ninth Millennium BP onwards.

1.July.1994, Istanbul

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69 Figure 1: General view of Aşıklı in 1993 (seen from SW to the N).

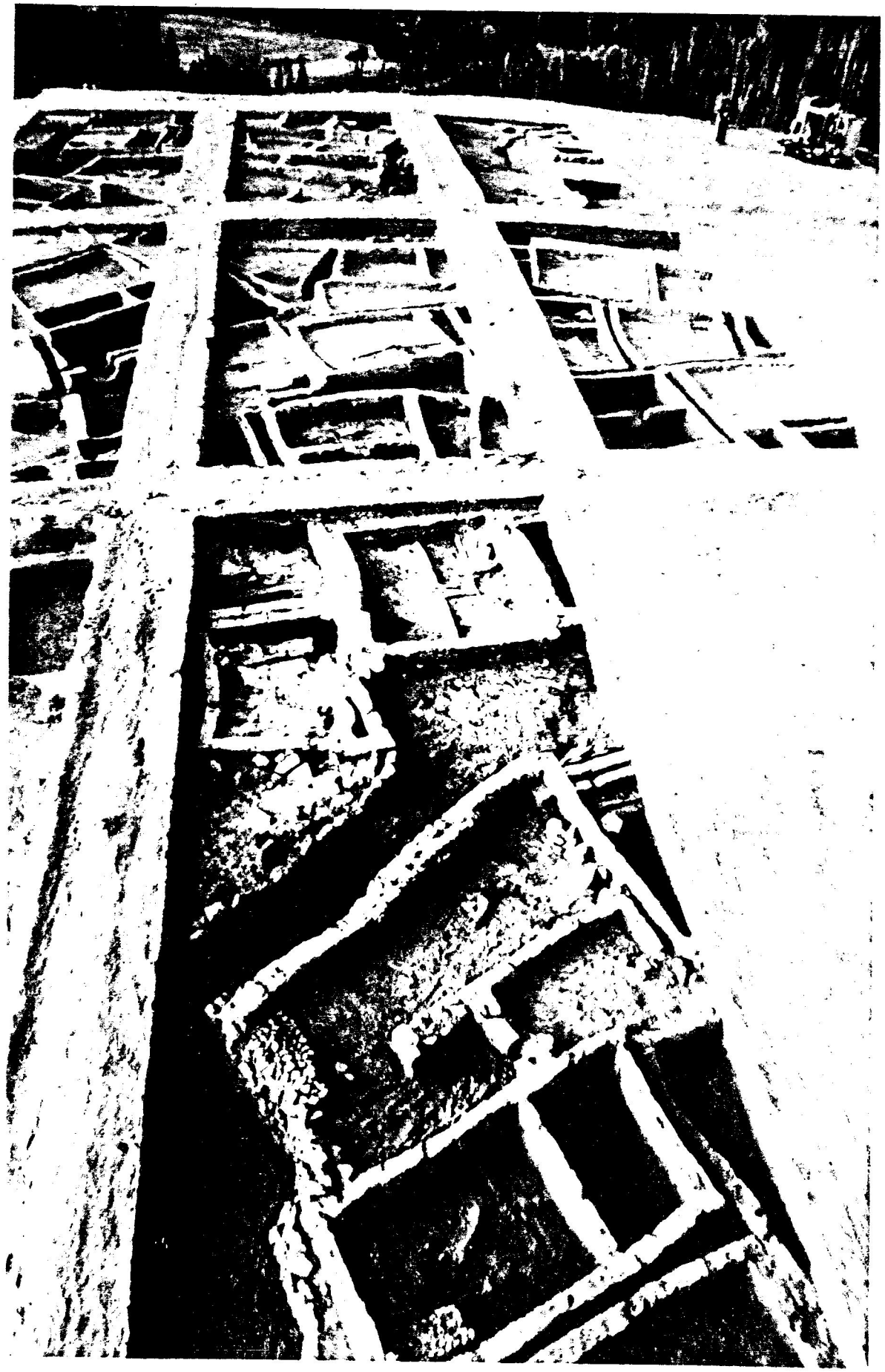

Figure 2: Air view of mud-brick buildings in layer 2. On the East room KE in trench 7-M (seen from South to the North).

Figure 3: The Earlier Settlement of Aşıklı on the shore of Melendiz river (seen from the NE).

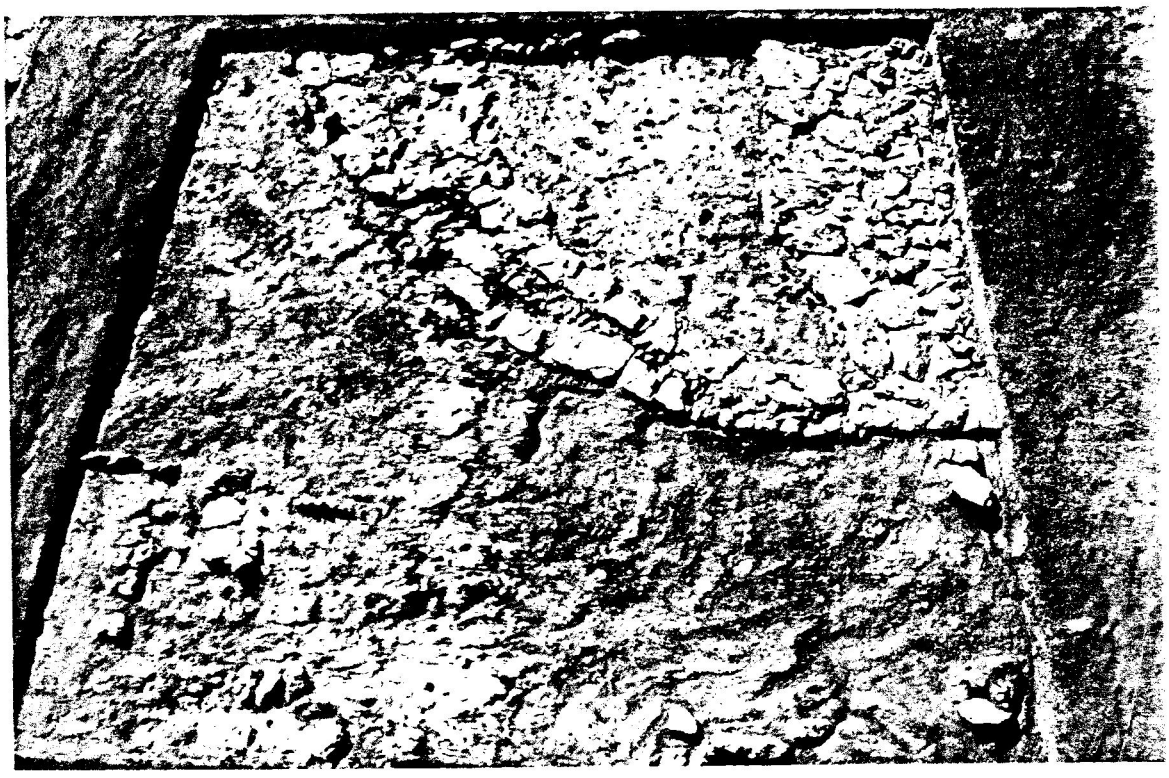

Figure 4: Monumental structure with rounded wall and paved floor made of stone.

Schematic plan of Aşıklı in 1992.

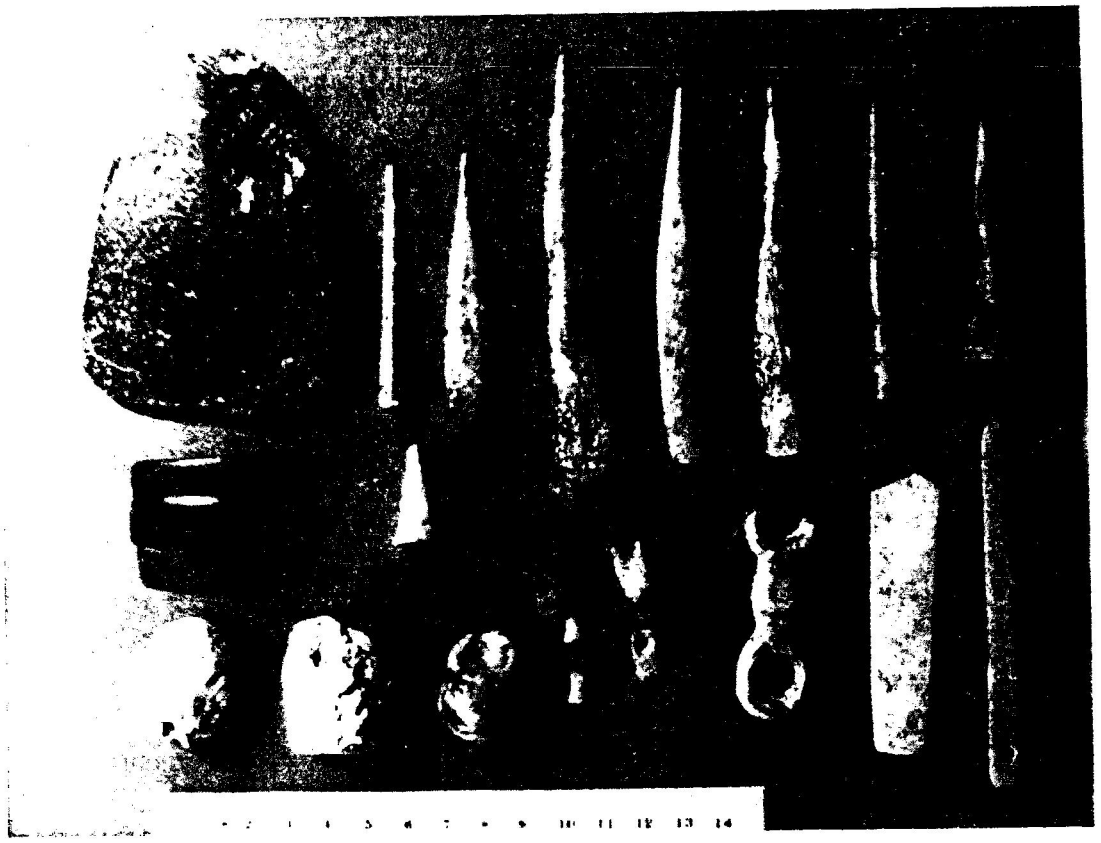

Figure 6: Bone, polished stone, obsidian and half-baked clay finds from Aşıklı.

Figure 7: Terracotta figurine (?) of Aşıklı in conical shape.

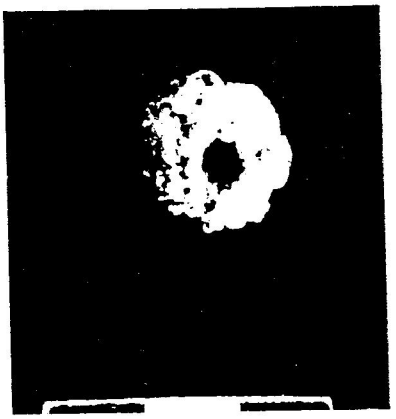

Figure 8: Massive copper bead (AH.91-343) found in room HB in trench 4-M as burial gift.

Figure 9: Room KE in trench 7-M.

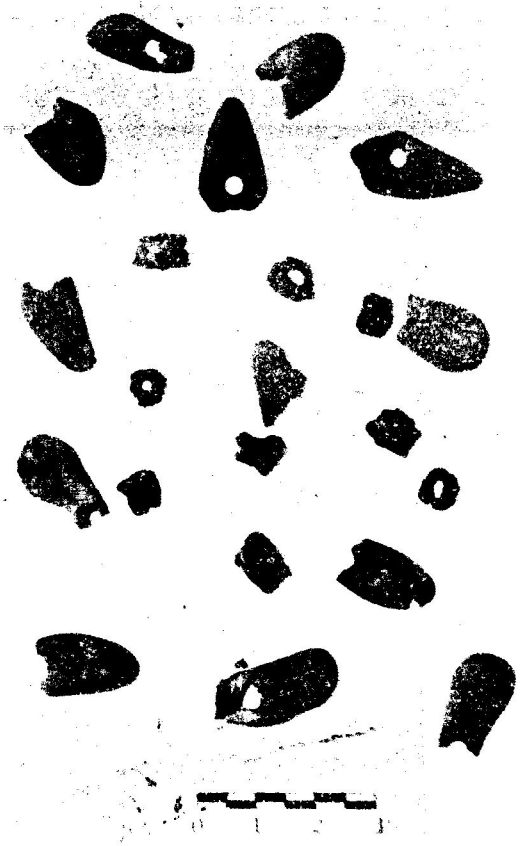

Figure 10: Beads made of copper and deer teeth (AH.92-105) discovered as burial gift in room KE in trench 7-M.

Uncalibrated ^{14}C Assesments of Aşıklı

(Libby's Standard Half-Life 5568±30)

Lab.	Find Spot:	Trench/Room	Layer/Phase	Uncl. Date in B.P.
GrN 19366	3P	HG 5/d-e		8400 ± 40
GrN 19365	3P	HG 2/e		8420 ± 30
GrN 19114	5L	CY 6/e	2	8515 ± 40
GrN 19358	4H	S 8/d	2	8550 ± 70
GrN 19866	4H	JV, 2/e		8560 ± 40
GrN 19359	4H	S10/e	1	8570 ± 70
GrN 20041	6N	KY, 5-8/b-e		8575 ± 20
GrN 19862	3P	HK, 1-3/b-c		8580 ± 50
GrN 19364	3P	HK 2/d		8585 ± 45
GrN 19121	2K	AN G under the wall	2	8590 ± 80
GrN 19361	6J	GD 7/b	2	8595 ± 60
GrN 18619	2R	AA 9/a-b	1b	8610 ± 55
P 1239	N Slope			8611 ± 108
GrN 19362	6J	GD 8-9/c	2	8630 ± 30
GrN 19867	2R	LS, 7/g		8630 ± 50
GrN 19863	7L	JA, 5-6/b		8640 ± 20
GrN 19861	7J	JA, 3/g		8670 ± 60
GrN 19363	4H	C 1/g	2b	8675 ± 25
GrN 19360	4H	C 7 Fire place	2	8695 ± 25
GrN 19115	4J	EN 8/k	2	8710 ± 100
GrN 19117	2K	AN 10/c	2	8710 ± 130
GrN 18620	3J	AM 2/h-i	2	8720 ± 55
GrN 19860	7J	JA, 6/i		8720 ± 50
GrN 19870	6N	KY, 5-8/b-e		8720 ± 80
GrN 18618	3J	İ 4-5/g	2b	8725 ± 50
GrN 18617	4H-G	E	2	8730 ± 45
GrN 19869	6O	LB, 6-7/b		8740 ± 70
GrN 19118	2K	AN 10/c	2	8760 ± 45
GrN 19119	2K	AN	2	8760 ± 40
GrN 19858	4H	JY, 7-9/c		8770 ± 90
P 1242	NW Slope			8778 ± 128
P 1241	NW Slope			8793 ± 127
P 1238	N Slope			8807 ± 128
GrN 19120	2K	AN 9/b	2	8815 ± 70
GrN 19865	4H	JY		8880 ± 70
GrN 19116	2J	FF 6/b	2	8920 ± 50
P 1240	NW Slope			8958 ± 130

Figure 11: Radio-Carbon Assessments of Aşıklı.

Uncalibrated ^{14}C Assesments of Aşıklı

(Libby's Standard Half-Life 5568±30)

Lab.	Find Spot:	Trench/Room	Layer/Phase	Uncl. Date in B.P.
GrN 19868	7J	JA,21,-0.95/1.29		8530 ± 110
GrN 20355	3R	NM,-9.70	8e	8550 ± 60
GrN 20356	14AB	NV,-14.63		8560 ± 60
GrN 20351	5J	BI,-1.79	2b	8670 ± 40
GrN 20354	4J	EN,-2.47	2a	8710 ± 70
GrN 20352	4K	CK,-3.25	2c	8720 ± 40
GrN 20684	14AB	NV,-14.63		8720 ± 70
GrN 20353	4G	MS,-4.92	2e	8740 ± 60
GrN 20349	4H	MS,-4.68	2e	8840 ± 50

Figure 12: Radio-Carbon Assessments of Aşıklı.

NAA AND AAS ANALYSES OF COPPER SAMPLES OF AŞIKLI

(Kindly Provided by E. Pernicka and by H. Özbal)

NAA Analyses

(*Cu in %, all other trace elements in ppm*)

No. of Sample and find-spot	Cu	Sn	As	Sb	Co	Ni
1.HDM.1799/AH.91-343/A (Room HB, 4-M 5/h) malachite	44	<140	580	0.16	8.5	7
2.HDM.1800/AH.91-194/A (Room GM, 4-L, 7/b)	79	<43	93	0.92	1.8	<12

	Ag	Au	Fe	Zn	Se
1.	11.1	<0.020	1170	16.6	3.6
2.	1210	<0.010	<160	10.7	<0.8

	Ir	Te	Cr	Hg	Bi
1.	<0.002	<17.0	11.1	2.0	nd
2.	<0.003	<13.0	7.3	228	nd

	Pb
1.	nd (tr.in ppm after Begemann)
2.	nd (tr.in ppm after Begemann)

AAS Analysis

(*All elements in %, only Au in ppm*)

	Cu	Sn	As	Sb	Co	Ni
3.BU.93.206/AH.92.105/A (Room KE, 7-M)	98.6	0.32	0.31	0.11	0.01	0.01

	Ag	Au	Fe	Zn	Se	Ir
3.	0.02	255	0.03	0.0	nd	nd

	Te	Cr	Hg	Bi	Pb
3.	nd	nd	nd	0.12	0.02

Figure 13: Neutron Activation and Atomic Absorption Analyses of copper samples of Aşıklı.