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Chapter 17

The Metallic Finds from Çatalhöyük: A Review and Preliminary New Work

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The metallic artifacts from Çatalhöyük are of particular importance as they constitute some of the earliest examples known. Metal finds have been recovered from as early as Level IX (South K), spanning to Level II, with VII and VI (South M-O) being the most productive (Mellaart 1964, 111). Radiocarbon dating of the archaeological sequence at Çatalhöyük suggests an occupation phase from *c.*7400–6200 cal BC, which was further refined by a programme of AMS radiocarbon dating to the range *c.*7400–5600 BC (Bronk Ramsey *et al.* 2009; Cessford 2001; 2005c; Mellaart 1964). The concentration of metallic finds from Levels South M-O has been dated to *c.*6600–6450 BC. Despite receiving a great deal of attention, very little research has been conducted on these finds (Neuninger *et al.* 1964; Sperl 1990).

Starting a new approach, three Neolithic copper-based artifacts from recent excavations were selected for further investigation. Before introducing the study of these artifacts, a brief overview will be presented of evidence for early metallurgy in Anatolia in order to contextualize the finds from Çatalhöyük. The finds from Mellaart's excavations will be reviewed before introducing those resulting from recent excavations. Finally, the preliminary investigation into the three copper-based artifacts will be presented with a discussion of the results.

Early Neolithic metallurgy in Anatolia and Mellaart's Çatalhöyük

The origins and development of metallurgy in Eurasia continue to be the subject of ongoing discussion full of debate. With the recent identification in the Balkans of the earliest smelting site known to date (Radivojević *et al.* 2010), the issue of diffusion vs independent origins of metallurgy has received renewed attention (Roberts *et al.* 2009; Roberts 2011). The Anatolian region harbors some of the earliest known metalwork from prehistory (Çambel 1980; de Jesus 1980; Pernicka 1990; Stech 1999; Tylecote 1976; 1987), and the dating of the finds from Çatalhöyük make it a site of particular importance for this debate. Much of the debate hinges on the identification of extractive metallurgy, which uses metal smelted from ores, as opposed to the use of native copper procured from the environment as part of a purely Neolithic exploitation of the landscape.

The earliest evidence for metal use

The most recent and up-to-date compilation and appraisal of the evidence of early metal use is given by Roberts (*et al.* 2009; Roberts 2011). Malachite objects, such as the bead from Rosh Horesha (southern Israel) and the pendant from Zawi Chemi (Shanidar, northern Iraq) provide clear evidence for the working of copper minerals as early as the proto-Neolithic (Bar-Yosef Mayer & Porat 2008; Solecki 1969), also implied at other sites in eastern Turkey, such as Hallan Çemi and Çayönü Tepesi (Rosenberg & Davis 1992; Özdoğan & Özdoğan 1999). The earliest known annealed native copper work appears towards the end of the 9th millennium BC at Çayönü Tepesi (eastern Turkey) with its array of beads and pins (Maddin *et al.* 1991; 1999; Özdoğan & Özdoğan 1999). Beads made of native copper dating to the 8th millennium BC have been recovered from Aşıklı Höyük (Yalçın & Pernicka 1999) in Turkey, and later examples from Hacılar and Can Hasan are dated to the 7th millennium (Esin 1999; French 1962; 1967; Mellaart 1960; Yalçın 2000). From this point onwards, copper artifacts begin to appear throughout the Near East.

The metallic artifacts and associated non-metallic finds from Çatalhöyük were first reported in 1962. The earliest finds consist of copper-mineral beads recovered from burials, where Bozkir is suggested as a material source (Mellaart 1962, 52, 55). The second season of Mellaart's excavations uncovered an array of copper finds from Levels VII-VI (Mellaart 1963). Beads, pendants and tubes (around wooden pegs), all made from copper, were recovered from Level VII (South M), and similar items were recovered from House 5 and 25 in Level VI (Mellaart 1963, 44, 99–101). In Level VI, copper tutuli were found with surviving textile, as well as carbonized fabric fragments, which have been interpreted as thin sheet encasings for the end sections of string skirts to weigh them down (Mellaart 1963, 101). In addition to these finds, finger rings also appeared in Level VI (South N-O), as well as objects tentatively identified as pins and awls in Level II (Mellaart 1964, 95, 114). The beads were confirmed

Sample	Analysis	Cu	As	Ag	Bi	Total
		all in wt%				
7575.x17-S2	1	98.9	0.028	0.040	bdl	99.0
	2	96.8	0.028	bdl	0.022	96.9
	3	97.2	0.025	0.057	0.020	97.4
	4	97.4	0.015	0.047	bdl	97.5
	5	98.5	0.023	0.064	bdl	98.6
	6	97.3	bdl	0.028	0.006	97.3
	7	98.4	bdl	0.023	bdl	98.5
	8	98.2	0.077	0.017	0.024	98.3
	9	97.4	0.087	0.076	bdl	97.5
	10	98.1	0.021	0.021	bdl	98.1
	Average	97.8	0.030	0.037	0.007	**97.9**
13079.x3-S1	1	95.9	0.004	bdl	bdl	95.9
	2	99.1	bdl	0.003	bdl	99.2
	3	96.8	bdl	0.017	0.033	96.9
	4	96.2	0.012	0.003	0.040	96.2
	5	96.1	bdl	0.010	0.020	96.2
	6	96.7	0.092	0.014	bdl	96.8
	7	94.9	0.025	0.044	bdl	95.0
	8	95.7	bdl	bdl	bdl	95.7
	9	96.6	bdl	bdl	bdl	96.6
	10	97.2	bdl	bdl	bdl	97.3
	Average	96.5	0.013	0.009	0.009	**96.6**
13079.x3-S2	1	96.6	0.058	bdl	0.005	96.7
	2	97.1	bdl	0.021	bdl	97.1
	3	96.1	0.049	bdl	bdl	96.2
	4	97.6	bdl	0.037	0.069	97.7
	5	95.1	0.066	bdl	bdl	95.2
	6	97.3	0.001	0.007	0.003	97.3
	7	99.4	bdl	0.001	0.037	99.5
	8	96.1	0.033	bdl	0.032	96.2
	9	95.9	bdl	bdl	0.046	95.9
	10	95.0	0.037	0.021	bdl	95.0
	Average	96.6	0.024	0.009	0.019	**96.7**

Table 17.1. *Raw EPMA-WDS data for each spot analysis conducted on the metal phase for each sample.*

as being made from a hammered native copper sheet that was divided into strips and then rolled to form the adornments, possibly in combination with annealing (Mellaart 1964, 114; Neuninger *et al.* 1964).

Beads and pendants, originally identified as lead, were also recovered from Level IX (Mellaart 1964, 111, 114). The beads were later shown, however, to be made from cerussite and galena, minerals rich in lead, not lead metal (Sperl 1990).

Earliest evidence for extractive metallurgy

The quest to identify the origins of metallurgy has a long tradition, with numerous changes of opinion over the decades regarding where and when metal smelting began. At present knowledge, the site of Belovode in eastern Serbia has produced the earliest securely dated evidence for copper smelting, at 5000 to 4600 BC (Radivojević *et al.* 2010). Two sites from Iran currently dated to the 5th millennium, Tal-i-Iblis and Tepe Ghabristan, have also yielded evidence of very early copper smelting in the form of slagged crucible fragments (Dougherty & Caldwell 1966; Majidzadeh 1979; Pigott 1999; Pigott & Lechtman 2003). This provides evidence for nearly contemporary copper smelting in the early 5th millennium both east and west of Anatolia, but at some considerable distance and leaving a conspicuous gap in between.

Against this backdrop, the finds from Çatalhöyük are of particular significance as they could potentially provide evidence of even earlier copper smelting, such as in House E (Mellaart 1964, Neuninger *et al.* 1964). Craddock (2000) presents an outline detailing the contentious nature of the evidence. Among the technical ceramics or 'crucible fragments' studied, the original investigation by Neuninger *et al.* (1964) identified copper slag and partially vitrified ore. Radivojević *et al.* (2010) echo the earlier assertions made by Muhly (1988) that the slag is more likely indicative of melting and refining copper, not smelting; a re-examination of the samples, however, may be the only means of shedding further light on the issue. The partially vitrified ore fragments in particular are yet to be fully explained. Whilst they may be small and indicate a "short-lived thermal impact", the conclusion that they are "not consistent with a well-mastered attempt to smelting" requires further exploration (Radivojević *et al.* 2010, 2776).

Copper sources

The most recent comprehensive collation of evidence for mining, metallurgy and copper deposit locations in Anatolia is provided by Wagner and Öztunalı (2000) and demonstrates that a large number of copper sources exist. The subject of copper provenancing is, in principle, of great interest for the material under study here, although this preliminary investigation will not pursue the topic further, nor explore the major deposits outside Anatolia. What is worth noting from the catalogue of copper deposits in Anatolia is the large number of those yielding native copper: Yakadere (Urvay), Yapraklı

Sample	Analysis	Fe	Zn	As	Se	Ag	Sn	Sb	Te	Pb all in µg/g
7575-X17-S2	a*	35	<5	750	12.6	11	<1	1.5	4.2	3.9
	b*	180	7	990	9.9	<1	<1	1.6	7.3	10.4
	c*	77	6	1100	12.2	<1	<1	1.7	8.2	6.3
	d1	<5	<5	15	7.0	390	<1	1.2	5.4	<1
	d2	<5	<5	17	10.0	450	<1	1.2	6.5	<1
	e1	<5	<5	<1	7.8	340	<1	1.0	8.8	<1
	e2	<5	<5	<1	<5	380	<1	<1	11.6	<1
	f	<5	<5	1	8.7	330	<1	1.1	9.0	<1
	g	<5	<5	2.9	11.0	300	<1	1.0	8.4	<1
	h	<5	<5	10	9.3	300	<1	1.5	10.5	<1
	i	<5	<5	3.1	8.1	320	<1	1.1	3.9	<1
	j	<5	<5	12	8.8	380	<1	1.2	5.4	<1
	k1	<5	<5	<1	9.0	265	16	1.2	<5	<1
	k2	<5	<5	3.9	11.4	2500	37	1.8	11.6	<1
	l	<5	<5	5.3	7.4	320	1.4	1.5	8.3	<1
	m	<5	<5	120	8.5	420	11	1.5	8.9	<1
	n	<5	<5	25	8.2	530	1.3	1.4	5.2	<1
	o	<5	<5	1	8.7	330	<1	1.1	9.0	<1
	p	<5	<5	2.9	11.0	300	<1	1.0	8.4	<1
	-1	<5	<5	10	9.3	300	<1	1.5	10.5	<1
	-2	<5	<5	3.1	8.1	320	<1	1.1	<5	<1
	-3	<5	<5	12	8.8	380	<1	1.2	5.4	<1
	-4	<5	<5	<1	9.0	265	16	1.2	<5	<1
	-5	<5	<5	3.9	11.4	2500	37	1.8	11.6	<1
	-6	<5	<5	5.3	7.4	310	1.4	1.5	8.3	<1
	Median	**<5**	**<5**	**5.3**	**8.8**	**330**	**<1**	**1.2**	**8.4**	**<1**
Sample	**Analysis**	**Fe**	**Zn**	**As**	**Se**	**Ag**	**Sn**	**Sb**	**Te**	**Pb** all in µg/g
13079-X3-S1	a	<5	<5	200	8.2	65	<1	1.1	6.8	<1
	b	<5	<5	120	10.1	65	<1	1.0	7.4	<1
	c	<5	<5	64	7.3	65	<1	<1	5.6	<1
	d	<5	<5	130	4.9	79	1.1	1.1	11.1	<1
	e	<5	<5	87	12.7	61	<1	1.2	9.7	<1
	f	<5	<5	120	6.9	74	<1	1.2	6.8	<1
	g	<5	<5	29	8.5	62	<1	<1	6.4	<1
	h	<5	<5	46	8.7	69	<1	1.1	7.2	<1
	i	<5	<5	92	10.7	76	<1	1.7	9.2	<1
	Median	**<5**	**<5**	**92**	**8.5**	**65**	**<1**	**1.1**	**7.2**	**<1**
13079-X3-S2	a	<5	<5	210	7.9	81	<1	1.1	5.4	<1
	b	<5	<5	200	8.8	83	<1	1.1	5.9	<1
	c	<5	<5	210	8.5	75	<1	<1	5.8	<1
	d	<5	<5	16	8.0	90	2.6	1.3	6.2	<1
	e	<5	<5	35	10.6	110	13	<1	5.1	<1
	f	<5	<5	90	11.2	88	2.1	1.1	7.0	<1
	g	<5	<5	54	8.0	74	<1	1.3	6.9	<1
	h	<5	<5	92	10.7	76	<1	1.7	9.2	<1
	i	<5	<5	165	10.6	72	<1	1.3	6.2	<1
	Median	**<5**	**<5**	**92**	**8.8**	**81**	**<1**	**1.3**	**6.2**	**<1**

Table 17.2. *Individual LA-ICPMS analyses of samples 7575.x17 and 13079.x3. All values are expressed as elements in µg/g. Signals unexpectedly high in iron and other elements are thought to include corrosion material (asterisked). Co, Ni, Pt and Bi were analysed and routinely found only at levels of less than 1 µg/g, with the exception of two individual measurements of 1.4 µg/g Pt in sample 7575.x17 (analysis d2 and e2).*

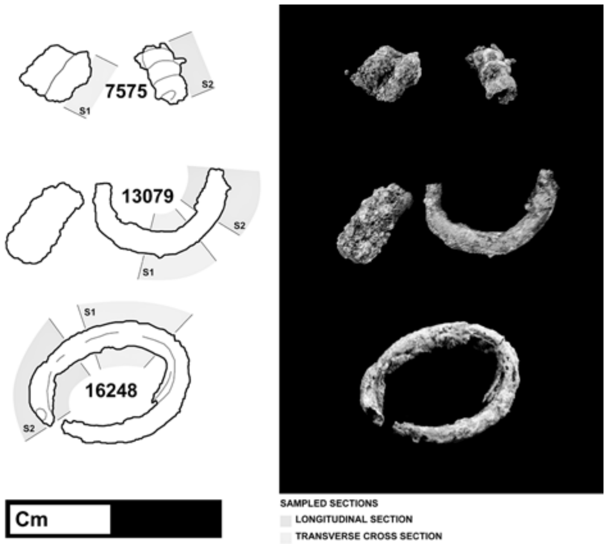

Figure 17.1. *Illustrations, showing the location of the subsamples obtained, with accompanying photographs of the three small finds being investigated: 7575.x17, 13079.x3 and 16248.x1 (for color version see CD).*

(Çankırı); Ergani Maden, Maden (Elazığ); Bakırtepe, Yusefeli (Artvin); Poluşaği, Pörtürge (Malatya); Kırmıztarla, Pörtürge (Malatya); Demirdağ (Purunsukköy), Divriği (Sivas); Derekütüğün, Bayat (Çorum); Üçoluk, Uğurludağ (Çorum); Çağşak (Çorum); Camlı, Suşehri (Sivas); Alıhoca, Ulukışla (Niğde); Halifeler, Anamur (Içel) and Bakırlı, Sandıklı (Aryon). Clearly, there was a very wide range of potential copper sources available to the early metal-using cultures, and native copper would have been easily accessible.

The finds from Çatalhöyük: recent excavations

Since excavations resumed in 1993, more metal finds have been made. The metal artifacts recovered from recent excavations were visually examined during the excavation season of 2009. Some artifacts, despite conservation efforts, displayed signs of active corrosion and have since become fragmented. The study and further conservation of these finds is now of paramount importance due to their significance. Over 50 of the finds suspected to relate to copper use, or subsamples thereof, were exported to the UCL Institute of Archaeology for further investigation. What is immediately apparent is the frequency of finds deriving from burials and pit fills. On both the East and West Mounds, the historical activities include Roman and Byzantine burials, which may account for a large portion of the copper-based finds recorded. Leaving these aside, the initial study presented here focuses on three pieces of clearly prehistoric copper metal. The aim of this work was to: 1) evaluate the level of corrosion, particularly to see whether sound metal is left for analysis, 2) determine the nature of this metal in preparation of further research, and 3) contextualize the findings within the wider archaeological framework.

The first sample comprises two small copper-based fragments (7575.x17) tentatively identified as beads. They were recovered from multiple inhumation burials eroding from a building in the 4040 Area. Two fragments, thought to form a ring, were selected as the second artifact for study from (13079.x3). This small find belongs to an infill layer that is situated above B.73, and is either below or belonging to B.62 in the TP Area. The final specimen selected for study is a complete ring fragment (16248.x1). The ring fragment was found in a dump deposit/layer belonging to the midden above B.75 in the South Area. Thus, all three finds presented here come from the Neolithic period of the East Mound.

Methodology

The aims of this study required a combination of optical and chemical methods to be used. After visual inspection of the entire assemblage and selection of the three objects chosen for analysis, two samples were obtained from each object to examine both transverse and longitudinal sections. These were mounted in a two-component epoxy resin and prepared as standard polished metallographic blocks. First, a metallographic examination of the unetched samples was carried out using an optical microscope to assess the microstructure and corrosion. Optical microscopy was performed in both plane-polarized (PPL) and cross-polarized (CPL) reflected-light modes using different magnifications (40x, 50x, 100x, 200x, 500x). Subsequently, the polished blocks were carbon coated for back-scattered electron microscopy (BSE imaging) and Electron Probe Micro-Analysis using Wavelength Dispersive Spectrometry (EPMA-WDS) of the metallic copper to establish major and minor element concentrations (Table 17.1). Finally, the samples were re-polished and the metal phases selectively analyzed by Laser Ablation-Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) for trace element determination (Table 17.2).

Sample preparation, metallographic examination and EPMA-EDS/WDS analyses were conducted at the Wolfson Archaeological Science Laboratories of the UCL Institute of Archaeology. Analytical precision and accuracy of the electron microprobe and the validity of the ZAF correction procedures were monitored through repeated analysis of reference materials relevant to the analysis of copper. The calibration of the microprobe was based on pure elements and simple compounds. Corrosion phases identified optically were confirmed by Energy Dispersive Spectrometry (EPMA-EDS); the data is provided in Table 17.3 with accompanying BSE images in Appendix 17.1 (on CD). LA-ICPMS analyses were performed at the Curt-Engelhorn-Zentrum Archäometrie

Sample	Image	Location	Cu	O	Cl	Ag	S	Si	Total	Formula (approx.)
			all in atom %							
7575.x17-S1	1	A (*n*=5)	50		50				99	**CuCl**
		B (*n*=5)	69	29	1.5			0.5	97	**Cu_2O**
		C (*n*=5)	69	30	0.6				96	**Cu_2O**
7575.x17-S2	2	A (*n*=3)	100						99	**Cu**
		B (*n*=5)	69	31					97	**Cu_2O**
		C (*n*=5)	51		49				97	**CuCl**
		D (*n*=5)	68	31	1.0				97	**Cu_2O**
	3	A (*n*=3)	69	31					98	**Cu_2O**
		B (*n*=3)	69	31					98	**Cu_2O**
		C (*n*=3)	50		50				99	**CuCl**
		D (*n*=3)	100						99	**Cu**
		E i	81		0.6	18.7			98	**Cu-Ag**
		E ii	48		18.7	33			86	**Cu-Ag-Cl**
		E iii	67		28	4.9			89	**Cu-Ag-Cl**
	4	A	88				12.5		98	**Cu-sulphide?**
13079.x3-S1	5	A (*n*=5)	71	29					97	**Cu_2O**
		B (*n*=5)	50	0.7	50				96	**CuCl**
		C (*n*=5)	71	28	1.4				95	**Cu_2O**
		D (*n*=3)	59		41				90	**Cu-chloride?**
	6	A (*n*=3)	51		49				94	**CuCl**
		B (*n*=3)	71	29	0.4				97	**Cu_2O**
		C (*n*=3)	100						99	**Cu**
13079.x3-S2	7	A (*n*=5)	50		50				96	**CuCl**
		B (*n*=5)	70	29	0.8				94	**Cu_2O**
	8	A (*n*=2)	50		50				97	**CuCl**
		B (*n*=2)	68	31	0.8				95	**Cu_2O**
		C (*n*=3)	100						98	**Cu**
16248.x1-S2	9	A (*n*=2)	68	31	0.3				99	**Cu_2O**
		B (*n*=2)	21	53	0.3			25	89	**$CuSiO_2$**
		C (*n*=2)	36	47	17.6				93	**Cu-oxy-chloride**
		D (*n*=2)	38	62	0.8				86	**Cu-carbonate?**

Table 17.3. *Average EPMA-EDS data obtained from multiple area analyses from separate phases (*n*=number of analyses).*

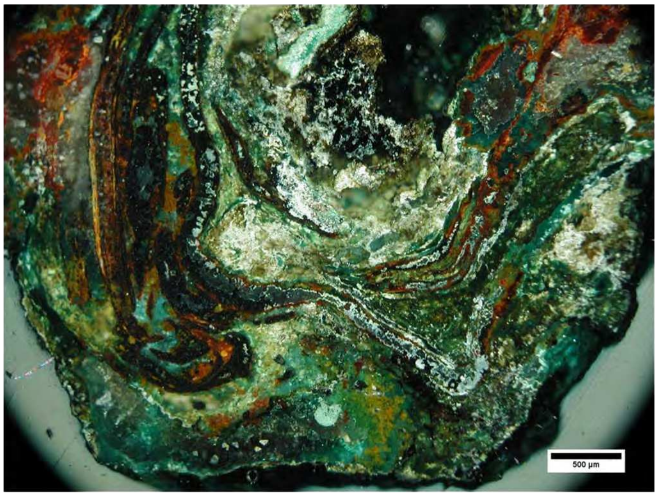

Figure 17.2. *Optical micrograph of the transverse section (S1) of the first piece of 7575.x27, providing an overview of the internal structure. CPL, 40x (for color version see CD).*

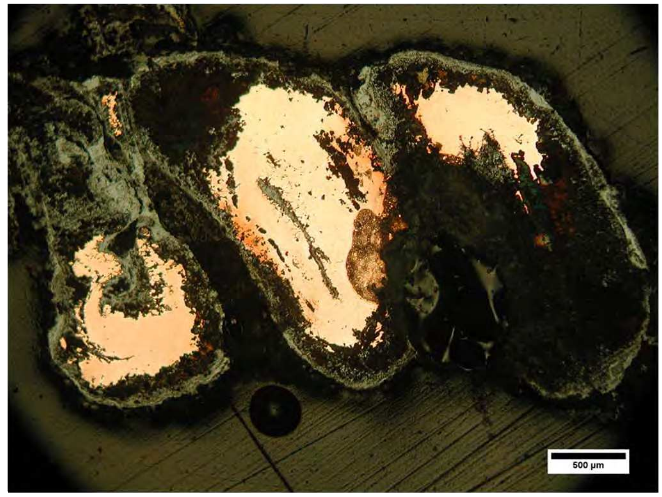

Figure 17.3. *Optical micrograph of the longitudinal section (S2) of the second piece of 7575.x17, highlighting the three segments identified macroscopically along with the alteration of the exposed surfaces by corrosion. PPL, 40x (for color version see CD).*

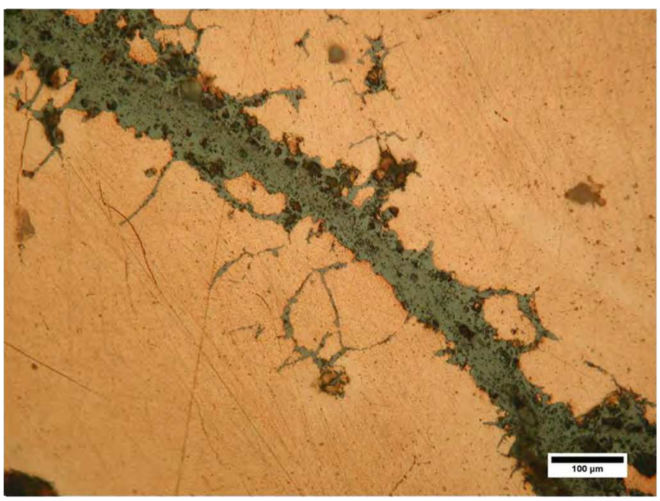

Figure 17.4. *Optical micrograph of S2 (7575.x17) showing polygonal grains in the metallic phase as outlined by intergranular corrosion. PPL, 500x (for color version see CD).*

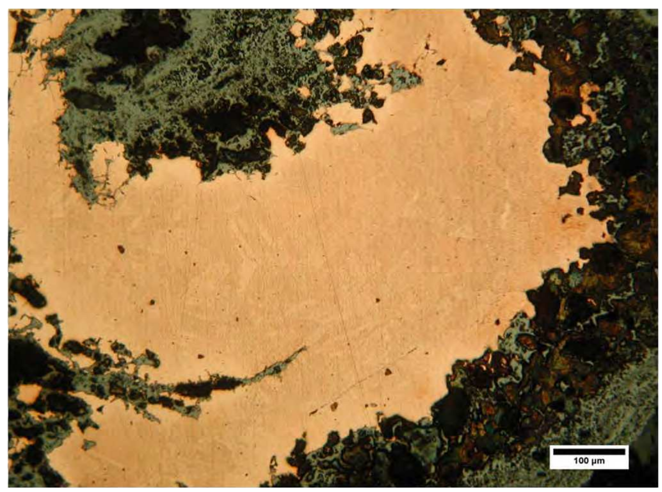

Figure 17.5. *Optical micrograph of the unetched sample S2 (7575.x17) revealing aspects of the microstructure: polygonal grains exhibiting well developed annealing twins consistent with hammering and annealing. PPL, 200x (for color version see CD).*

in Mannheim, Germany. For quantification, a modified approach developed for trace element analysis of gold (Kovacs *et al.* 2009) was applied, using several certified reference materials with copper as matrix.

Macroscopic description

The finds being studied here are presented in Figure 17.1, showing also the location of the samples obtained from each artifact. 7575.x17 consists of two pieces. It is not clear whether they represent two fragmented segments of a single object, or two individual items accompanying one another. Both pieces consist of multiple portions that are consistent with a ribbed surface texture, where the divisions are angled and not perpendicular to the length of the objects, forming a characteristic 'beaded', or single-corded (twisted), appearance. The first piece (S1) consists of two distinct zones and the second (S2) has three.

13079.x3 also consists of two fragments. The first piece is cylindrical, displaying heavy corrosion with no apparent diagnostic surface features, and hence was not sampled. The

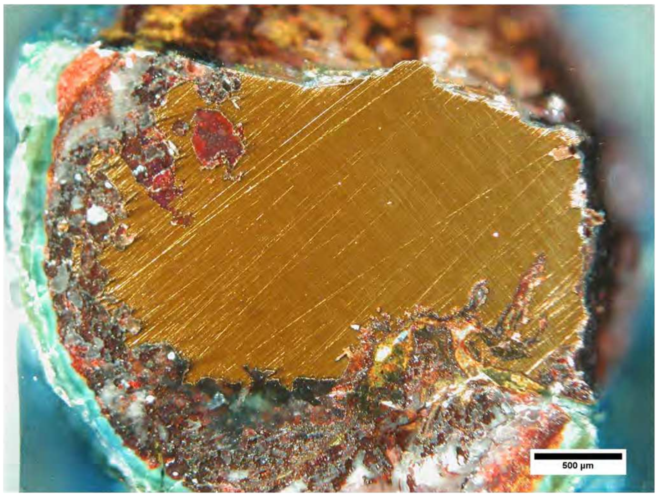

Figure 17.6. *Optical micrograph of the transverse section (S1) of the first piece of 13079.x3, revealing a circular form mostly consisting of an uncorroded metallic substrate with some surface corrosion: cuprite (yellow-red), copper chloride (green), atacamite (darker green). CPL, 50x (for color version see CD).*

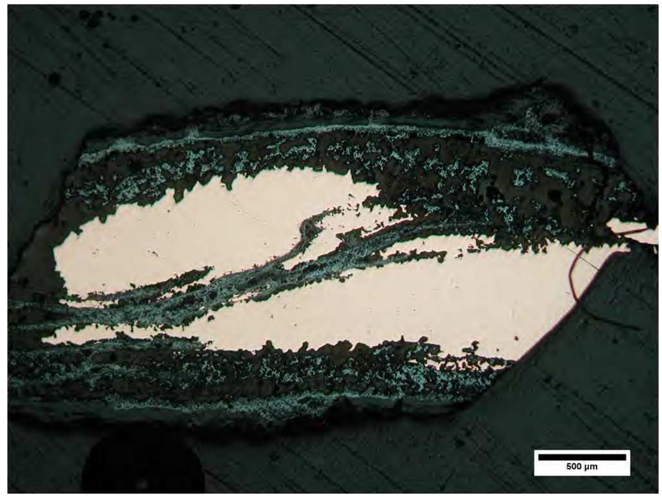

Figure 17.7. *Optical micrograph of the longitudinal section (S2) of the second piece of 13079.x3, showing the length of the object is tubular with a central void. PPL, 50x (for color version see CD).*

second piece, from which both samples (S1 and S2) were taken, was identified as a curved cylinder whose end sections displayed a spiral form consistent with a single rolled sheet. Should both pieces originate from the same object, it would likely have been a ring.

16248.x1 was also identified as a curved tubular cylinder that appeared to be formed from a single rolled sheet, as indicated by the end sections and the linear striation features observed along the length of the object.

Results

7575.x17

The optical study of the transverse section of the first piece of 7575.x17 (S1) showed the object was made from rolled copper sheet that has since completely corroded. The layers of copper sheet are clearly discernible, being preserved in secondary corrosion products (Fig. 17.2). The sheet forms a spiral (in cross-section) consisting of five or more concentric layers. Due to the heavy corrosion, it was not possible to describe the original microstructure of the copper metal.

The longitudinal section of the second piece of small find 7575.x17 (S2) confirmed the macroscopic identification of three ribbed segments. The surface of the object, as revealed in the longitudinal section, has altered to cuprite and copper chlorides, while the core preserves relatively large areas of metallic copper (Fig. 17.3). Polygonal grains could be observed in the metallic phase defined by intergranular corrosion (Fig. 17.4), and well-developed annealing twins are visible in the copper phase, indicating that the rolled copper sheet was worked by hammering and annealing (Fig. 17.5). Some strain lines appear to be visible, confirming that the object had been cold-worked. The grains do not appear to be flattened, indicating that the object was not left in its worked state at the end of production, but was finally annealed.

The metal is almost pure copper with 300 to 400 µg/g silver according to both EPMA and LA-ICPMS analysis. In addition, EPMA indicated a similar amount of arsenic, while LA-ICPMS analysis only found less than 15 µg/g arsenic in this sample. Given the higher sensitivity of LA-ICPMS compared to EPMA, we deem the latter results to be more reliable. Other elements sought for include iron and zinc, both of which were found to be below 5 µg/g, antimony at around 1 µg/g, and bismuth, lead, nickel and cobalt all below 1 µg/g. Most ablation points returned tin readings below 1 µg/g, but several recorded up to nearly 40 µg/g Sn. Several metallic inclusions were identified in the corrosion phase of S2, appearing with a heavy atomic weight in BSE mode. These were confirmed as silver, most likely precipitated as discrete particles during the corrosion of the slightly argentiferous copper. A few features of a lighter average atomic number were identified within the copper of S2; one was large enough to be analyzed and confirmed as a sulphide inclusion.

Incorporating the observations made during macroscopic examination and microscopic observations, 7575.x17 consists of two rib-textured copper objects that were formed from rolled copper sheet that had been worked and annealed. The difference in size and rib width between the two pieces indicates that they are likely to be separate objects, both of

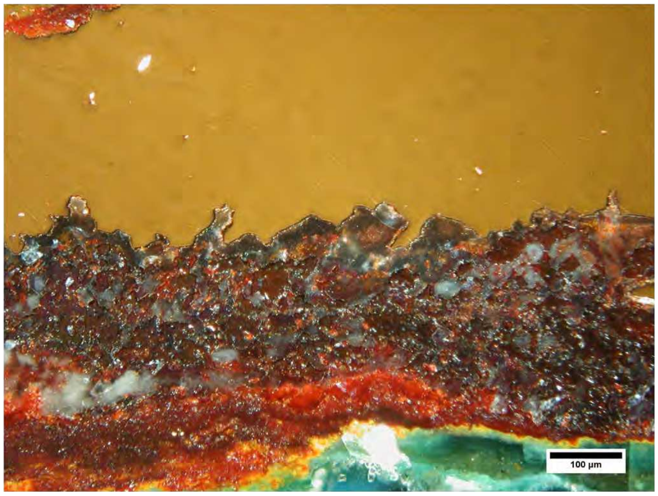

Figure 17.8. *Optical micrograph of S2 (13079.x3) revealing the polygonal grain structure at the boundary of the copper phase (dull yellow) with intergranular corrosion, as well as remnant grains visible within some of the other corrosion products: cuprite (yellow-red), copper chloride (green). CPL, 200x (for color version see CD).*

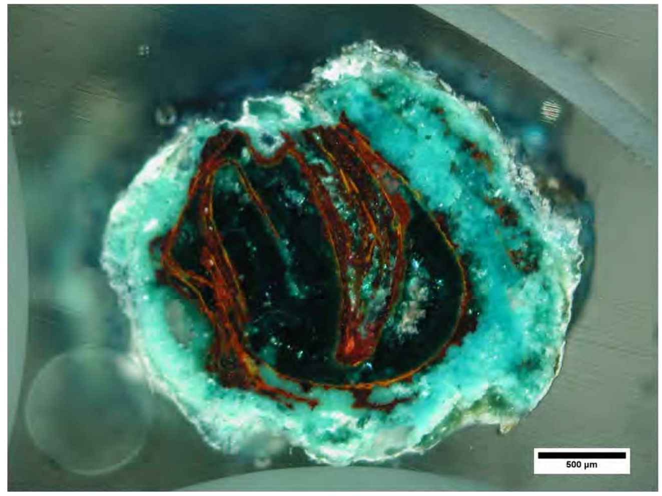

Figure 17.9. *Optical micrograph of the transverse section (S1) of 16248.x1, showing the internal structure and a surface heavily disrupted by copper chlorides (green). CPL, 50x (for color version see CD).*

which can be classified as beads. Only one retained sufficient metallic copper in the sectioned part to analyze, and was found to be pure copper with around 0.03 wt% silver as the main trace element.

13079.x3

The microscopic examination of the sample obtained from the first piece of small find 13079.x3 (S1) revealed that the object was originally almost perfectly circular in section and made from solid copper rather than from rolled foil (Fig. 17.6). The original surface of the artifact can be discerned at the boundary between the cuprite and copper chloride corrosion phases (Fig. 17.6). As well as the usual copper (I) chloride being confirmed, some areas of the outermost corrosion layer consisted of a copper (II) chloride hydroxide, similar to the mineral atacamite.

The longitudinal section of the second piece of small find 13079.x3 (S2) confirmed the earlier observations. Several striations in the corrosion products imply that the structure has been mechanically worked (Fig. 17.7). Intergranular corrosion on the boundary of the metallic phase, along with remnant grains clearly visible in the corrosion products (cuprite and copper chlorides), shows that the microstructure consists of polygonal grains (Fig. 17.8).

Both samples were analyzed by EPMA and LA-ICPMS and found to be made from pure copper. As expected of samples from the same object, S1 and S2 share very similar elemental compositions. Both analytical methods agree in their reported silver levels of 90 to 100 μg/g, but disagree in reported arsenic values. EPMA indicates around 200 μg/g As, while LA-ICPMS analysis only found around 100 μg/g (see Table 17.2). As before, the LA-ICPMS data is taken to be more reliable, since the EPMA data borders on the detection limits of the instrument. Similarly, relatively high levels of bismuth in this sample indicated by EPMA were not confirmed by LA-ICPMS, and are therefore considered spurious. The remaining trace element pattern mirror those reported for the sample from (7575), except for somewhat lower tin readings here.

16248.x1

Neither of the two samples obtained from 16248.x1 (S1 and S2) had a metallic phase preserved. The transverse section (S1) is circular in form (Fig. 17.9). The outer limits of the object have been heavily distorted as shown by the copper chlorides (Fig. 17.9). At a higher magnification, the concentric banding within the corrosion products becomes very clear (Fig. 17.10). The repeated bands are constituted by cuprite, and show that the object was originally formed from copper sheet. The original surface of the copper sheet delineated between the cuprite and copper chlorides indicates that the sheet has been folded several times before being rolled into a circular form (Fig. 17.10).

The longitudinal section of S2 confirms the observations made in the transverse section. The central portion of the corrosion is defined by a void, consistent with the object being tubular (Fig. 17.11). The banded structure within the corrosion products observed in S1 is also observed in S2 (Fig. 17.12). The edge of the copper sheet appears to be rounded, as indicated by the shape of the original surface outlined by the cuprite and copper chlorides (Fig. 17.13).

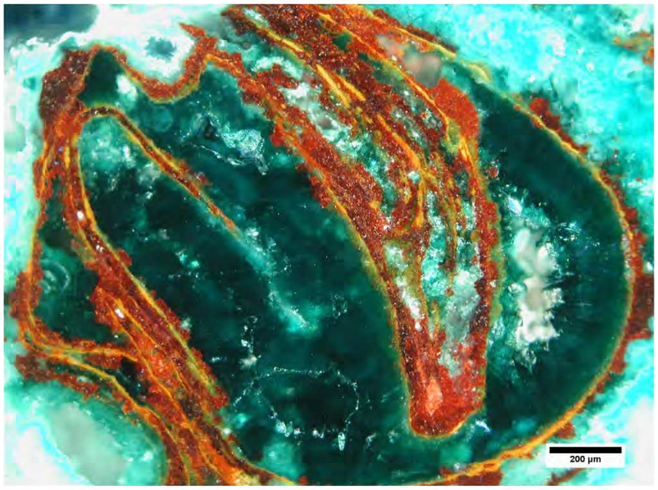

Figure 17.10. *Optical micrograph of S1 (16248.x1), revealing the concentric structure of the corrosion products of the internal structure of the object: cuprite (yellow-red), copper chloride (green) (for color version see CD).*

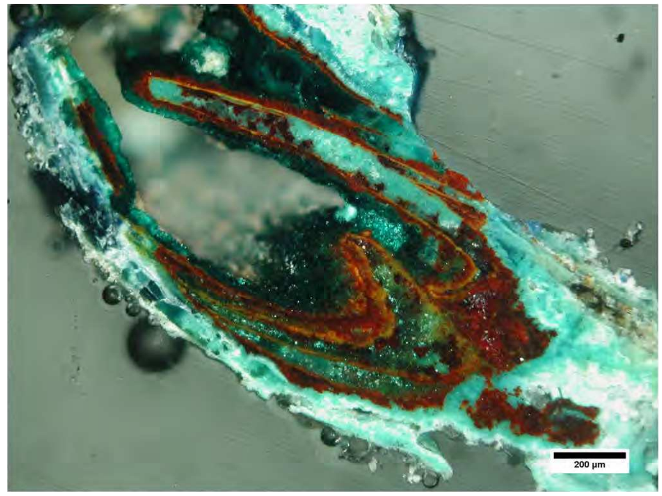

Figure 17.11. *Optical micrograph of the longitudinal section S2 (16248.x1), showing the central void and corrosion bands forming a tubular structure. CPL, 100x (for color version see CD).*

Despite the fact that no metal phase had survived in object 16248.x1, the corrosion products confirm that it was made from unalloyed copper metal. Within the corrosion products of S2, a copper silicate phase was identified. The conchoidal fractures, along with the stoichiometry, suggest that it is similar to dioptase (Table 17.3), a mineral which occurs in the oxidized zone of some copper deposits, but can also form during the corrosion of copper metal.

Discussion of results

The three Neolithic small finds presented in this study corroborate the evidence provided in previous analyses (Neuninger *et al.* 1964). The metal phases analyzed consist of very pure copper (99.9 per cent Cu) with only minor amounts of silver (100 µg/g and 300–400 µg/g, respectively), and around 100 µg/g arsenic in one sample only. Despite earlier assertions that native copper cannot be differentiated from smelted copper artifacts by chemical composition (Maddin *et al.* 1980), it has been shown more recently that this is possible with the analysis of certain trace elements at low concentrations (Pernicka *et al.* 1997; Yalçın & Pernicka 1999). The analytical results presented here strongly indicate that this is native copper. In particular, the very low concentrations of elements such as cobalt, nickel, arsenic, antimony and lead seen here would firmly suggest that the metal does not derive from smelted copper, which would be expected to contain much greater amounts of these. The presence of silver and arsenic in native copper at levels comparable to those found here, however, is well known and is therefore consistent with our interpretation.

Evidence for annealing can be seen by the presence of polygonal grains observed in the metal phase of 7575.x17, and also preserved in remnant form and ghost structures in the corrosion products of all samples. The strain lines and twins apparent in the copper phase of 7575.x17 indicate that the artifacts were shaped by a combination of cold-working and heat treatment. The study of the microstructure of the artifacts, therefore, provides some insight into the manufacturing of these objects. Unsurprisingly, these observations match those made in earlier studies (Neuninger *et al.* 1964).

The contexts of production, however, remain unknown. Although investigations into the use of fire and pyrotechnology at Çatalhöyük have been undertaken (Cessford & Near 2005; Harrison 2008; Chapter 9), their relationship to metallurgy still remains unclear. A more recent synthesis of the evidence from B.52 debates two opposing arguments in explaining the burning of buildings: intentional act, or accident (Twiss *et al.* 2008). Whilst plenty of attention has been paid to the subject, including addressing aspects of fuel consumption, no relationship has been sought between the supposedly repeated and deliberate action of burning buildings and the production of new materials. The possibility of regarding the 'house as kiln', or 'house as crucible', should not be ruled out. Such a suggestion requires further justification in the form of experimentation, but is worthy of exploration, as this may help towards explaining the absence of evidence for production technologies, as the very nature of the evidence itself would be ephemeral. The act of destruction and closure may not just mark the rebirth of a new building, but potentially the creation of new materials, too. The transformation of clay to ceramic, of ore to metal, may be directly related to a willful act of pyrotechnology – burning a building.

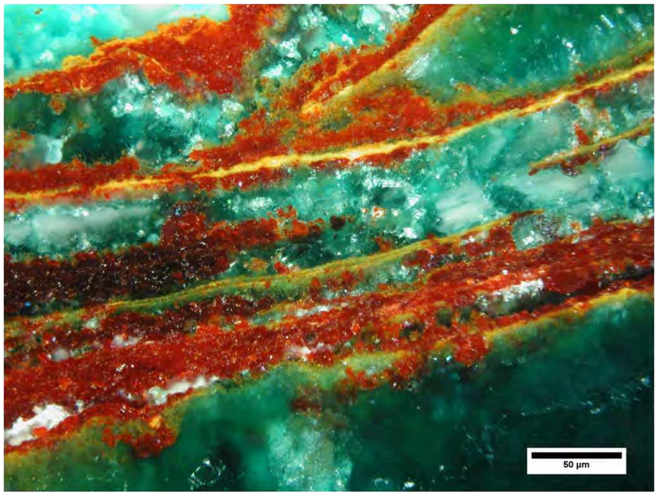

Figure 17.12. *Optical micrograph of S2 (16248.x1), showing the banded structure of the corrosion products of the internal structure of the object: cuprite (yellow-red), copper chloride (green). CPL, 500x (for color version see CD).*

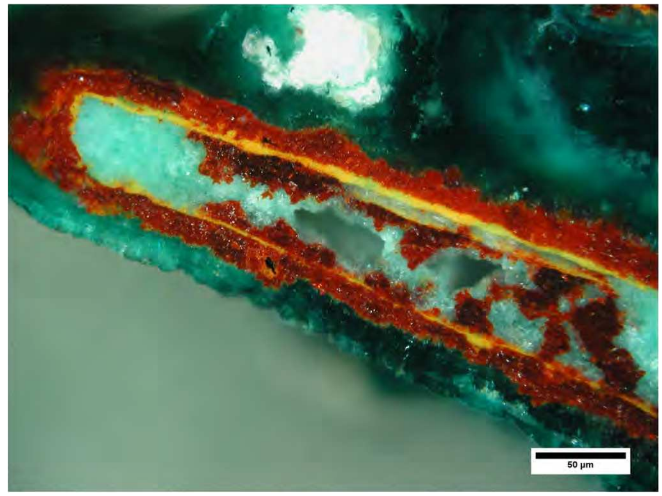

Figure 17.13. *Optical micrograph of S2 (16248.x1), highlighting the original surface of the artifact between the cuprite (yellow-red) and the copper chlorides (green). Internally, the cuprite highlights features of the microstructure in the form of remnant grain agglomerates. CPL, 500x (for color version see CD).*

Future work

The initial visual examination has determined that a methodical programme of X-radiography be undertaken to aid the identification of objects, as well as to assess their level of corrosion and hence their suitability for conservation and further study. The X-radiographs will provide invaluable guidance for this.

The absence of evidence for the use of smelted copper at Çatalhöyük, again confirmed in this study, underlines the necessity of re-examining the finds analyzed nearly half a century ago by Neuninger *et al.* (1964). In re-examining some of Mellaart's finds, it is hoped that the long-standing debate over the nature of the supposed copper slag and other metallurgical residues that have been discussed in association with early evidence for metallurgy can be resolved.

Our ongoing study also aims to further identify more metallic, and associated, finds for future study. The purpose of selecting new specimens for study will be to enrich our understanding of some of the earliest evidence for metal use known, as well as to contextualize this knowledge in the wider framework of Anatolia and the Near East. The ongoing efforts orientated towards resolving aspects of dating and chronology at the site (Bayliss & Farid 2007; 2008; Volume 7, Chapter 3) will, no doubt, influence the choice of finds selected for future research. Thus, the work presented here is intended to mark the beginning of a renewed research programme into the early metallurgy of Çatalhöyük, which we look forward to publishing in the future.

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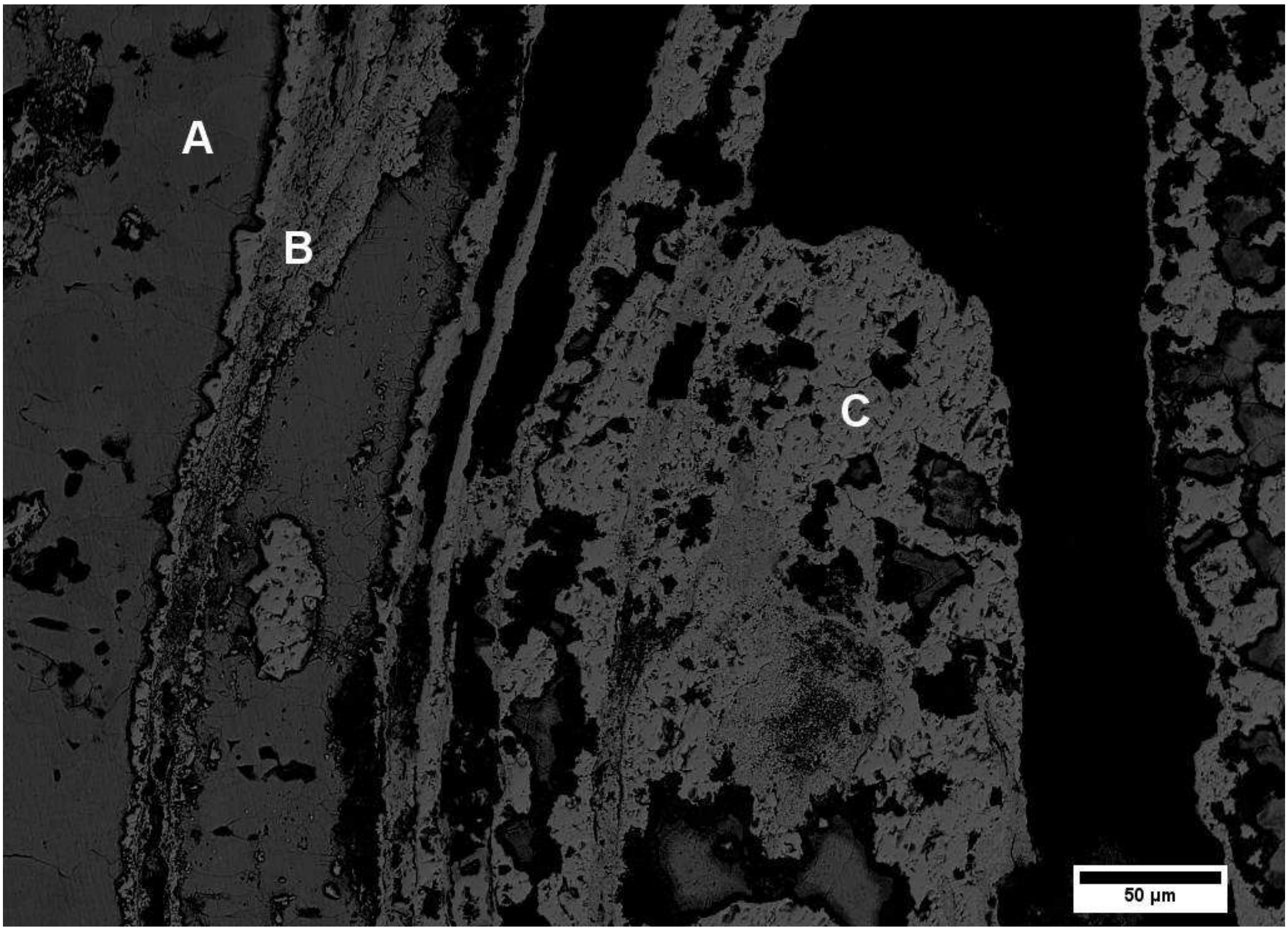
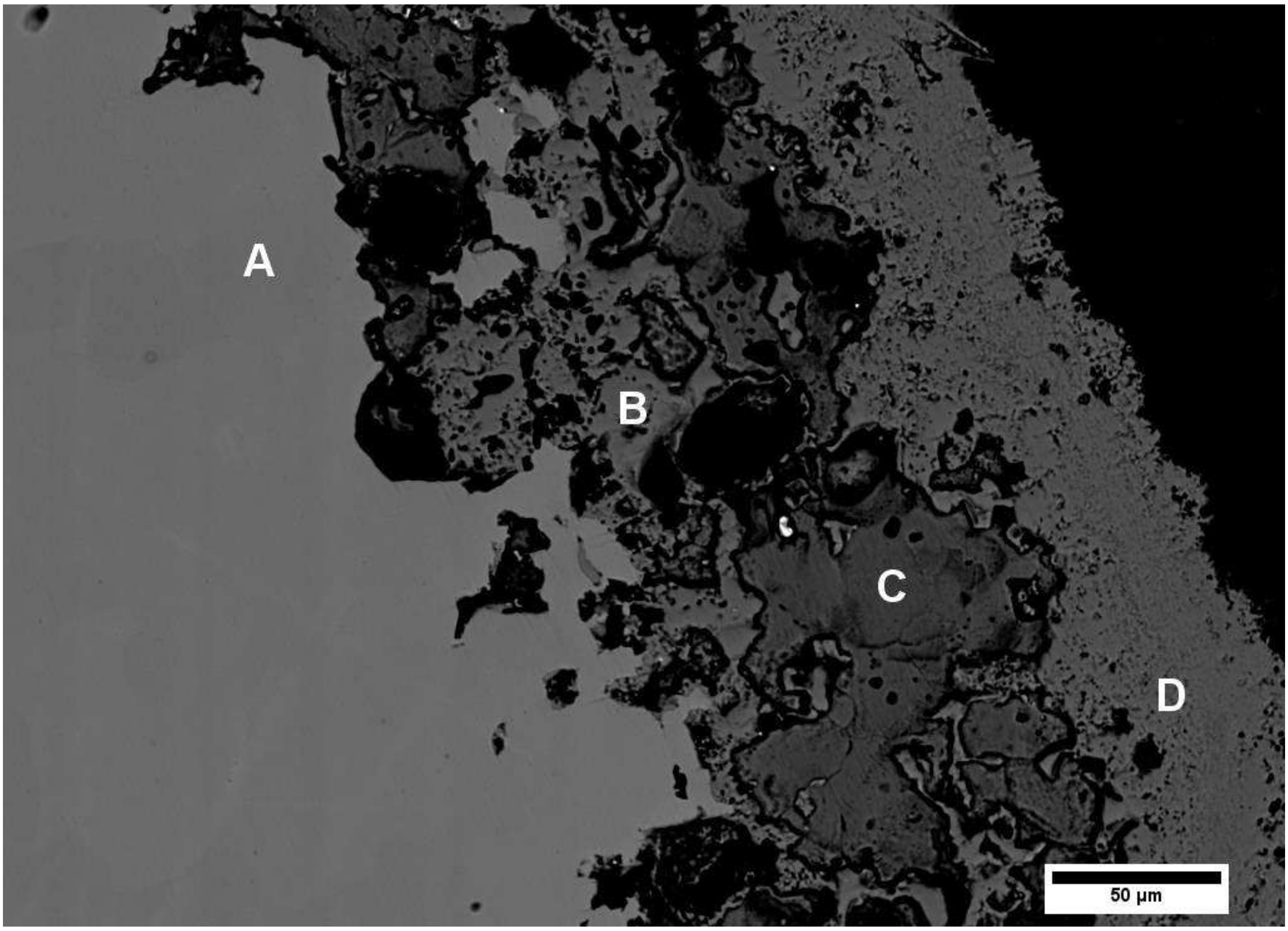
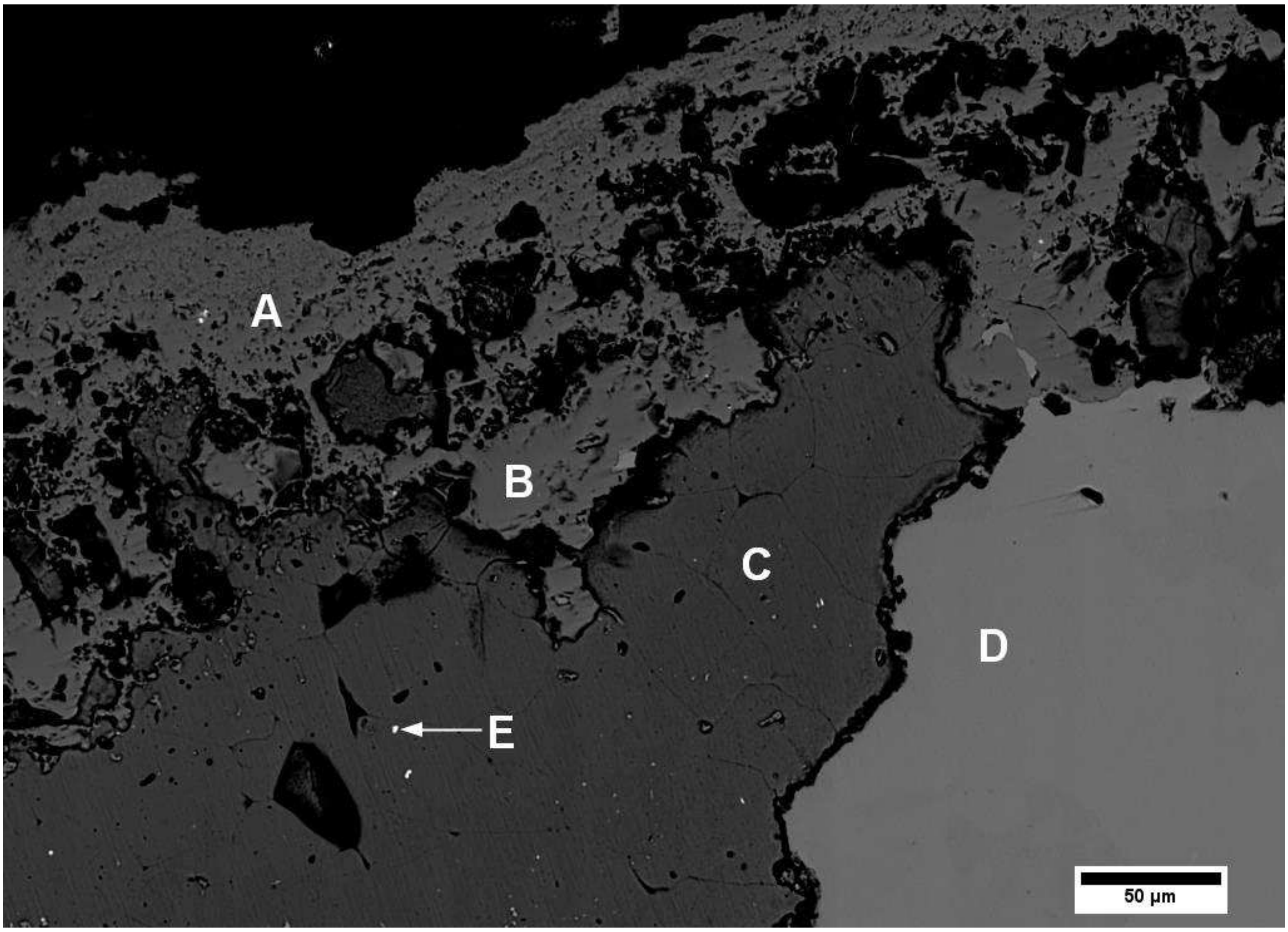


Appendix 1_Image 1_7575_S1 analyses.jpg



Appendix 1_Image 2_7575_S2 analyses_i.jpg



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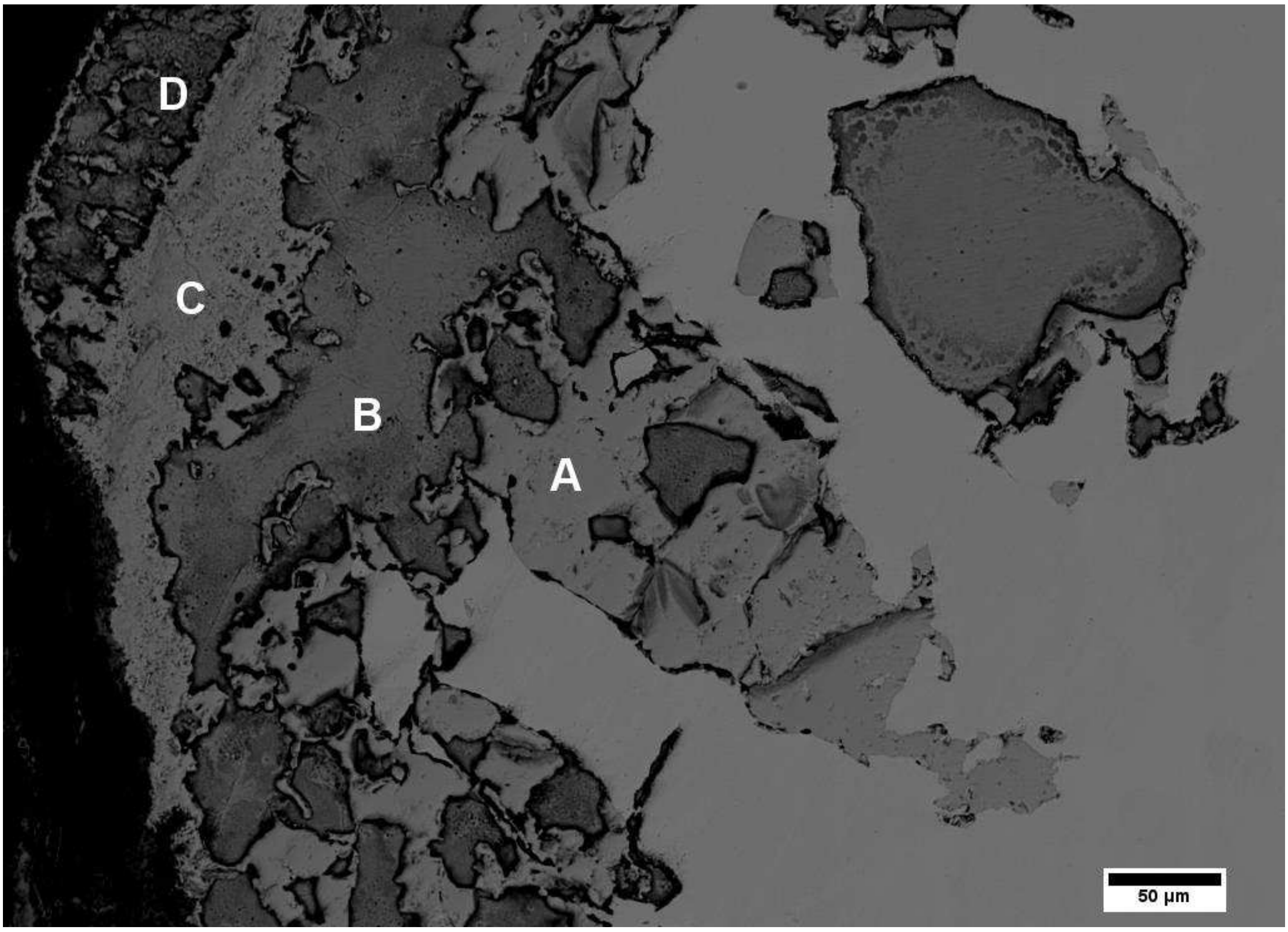

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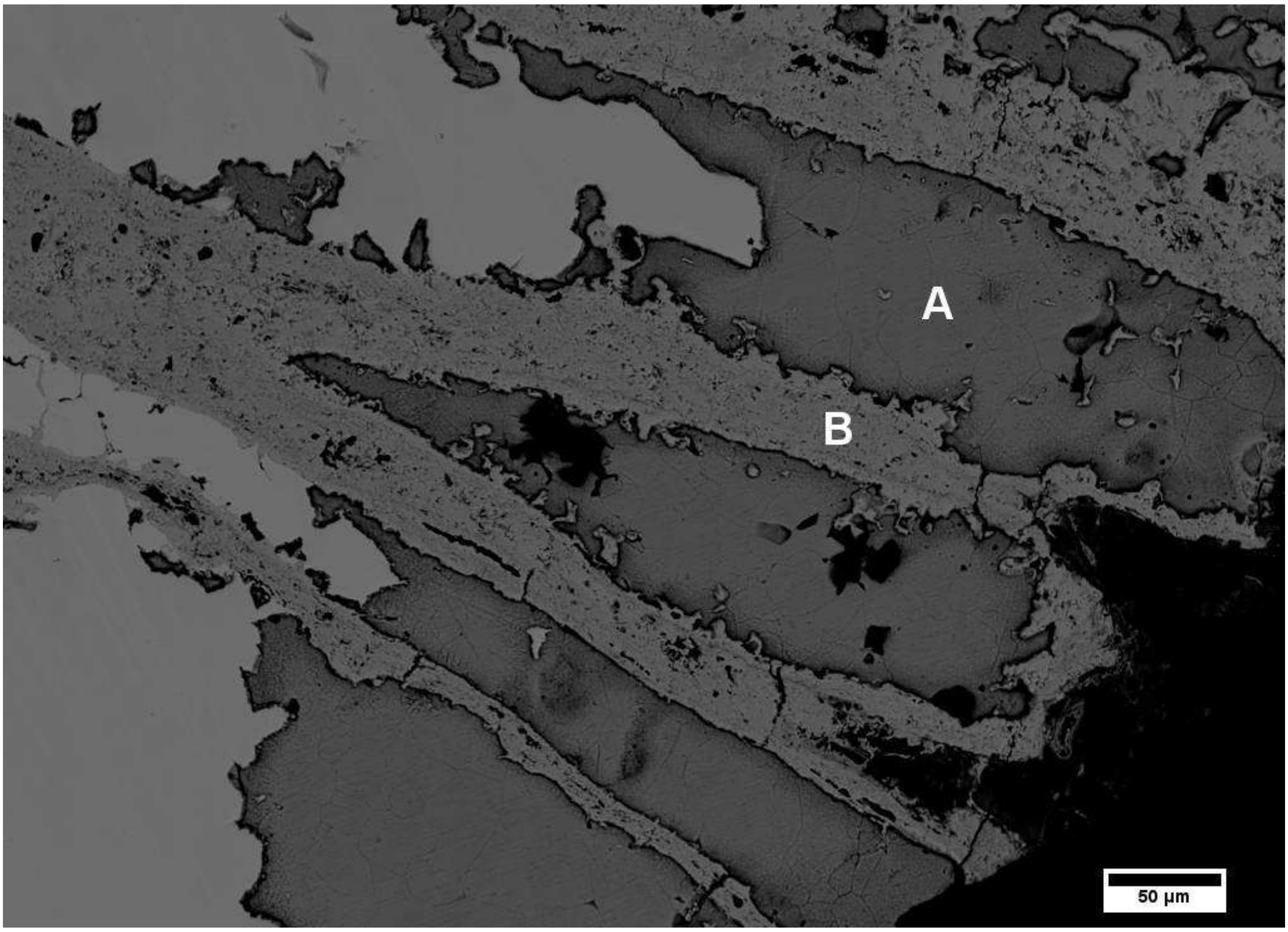

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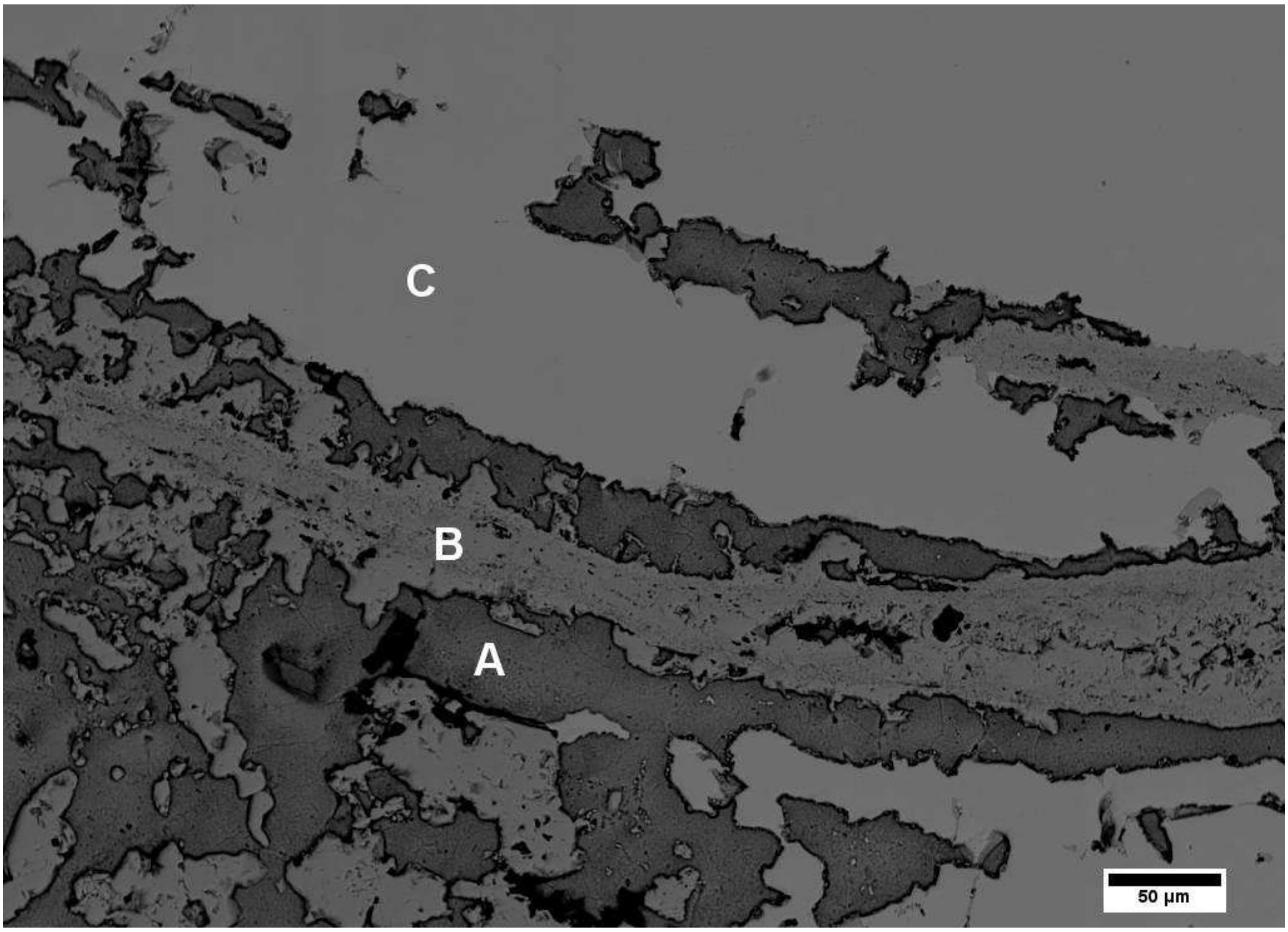

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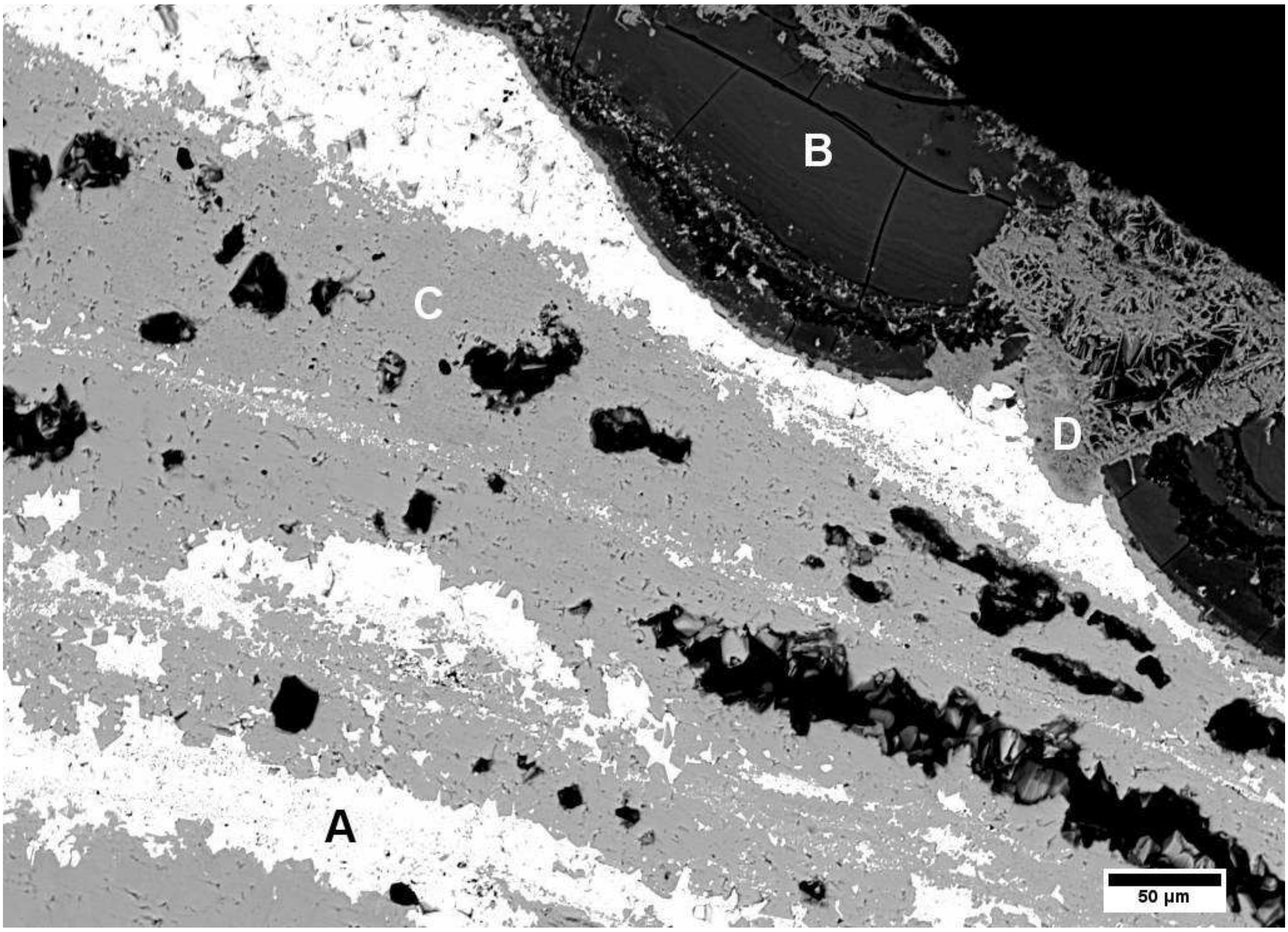

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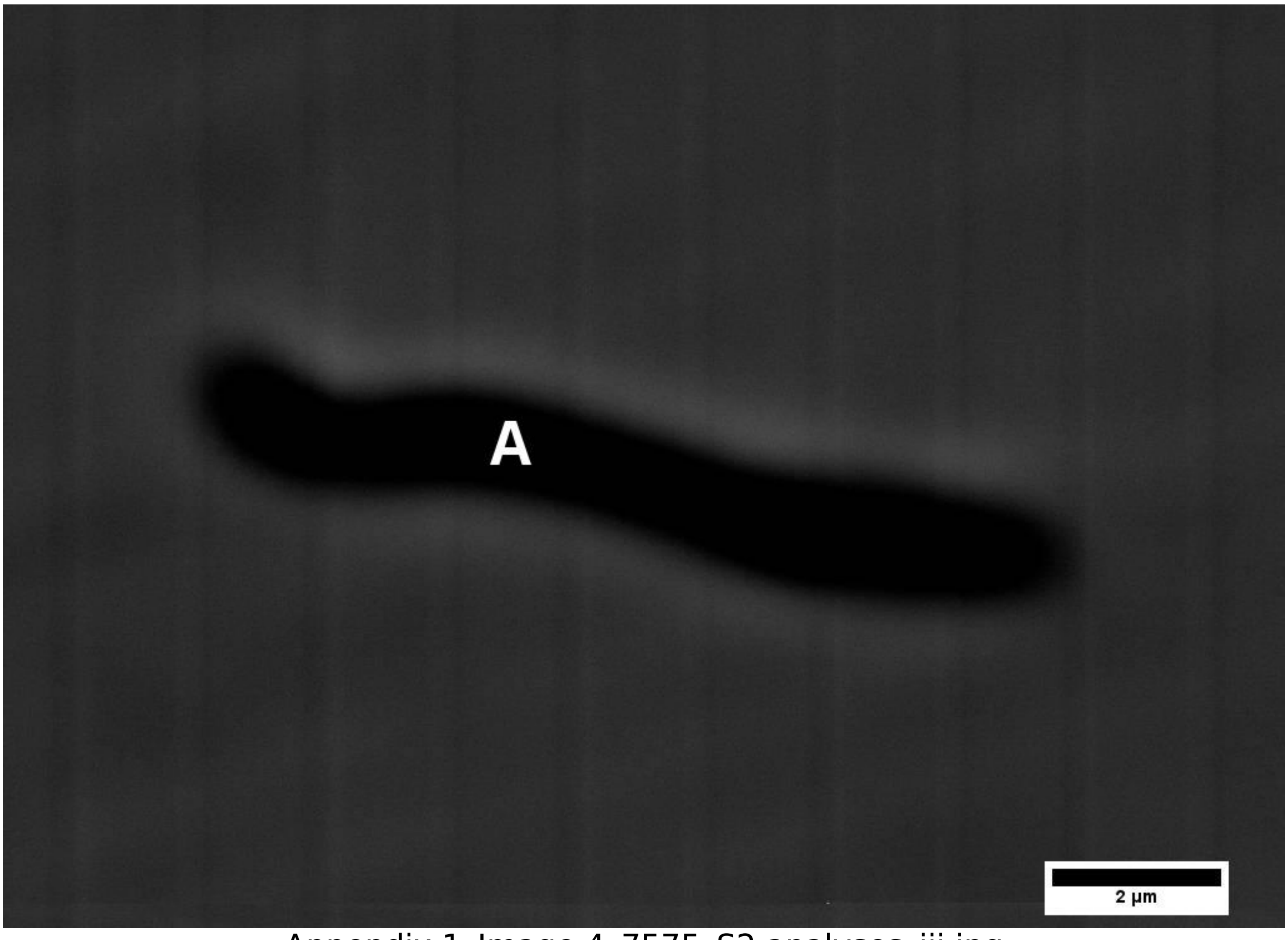

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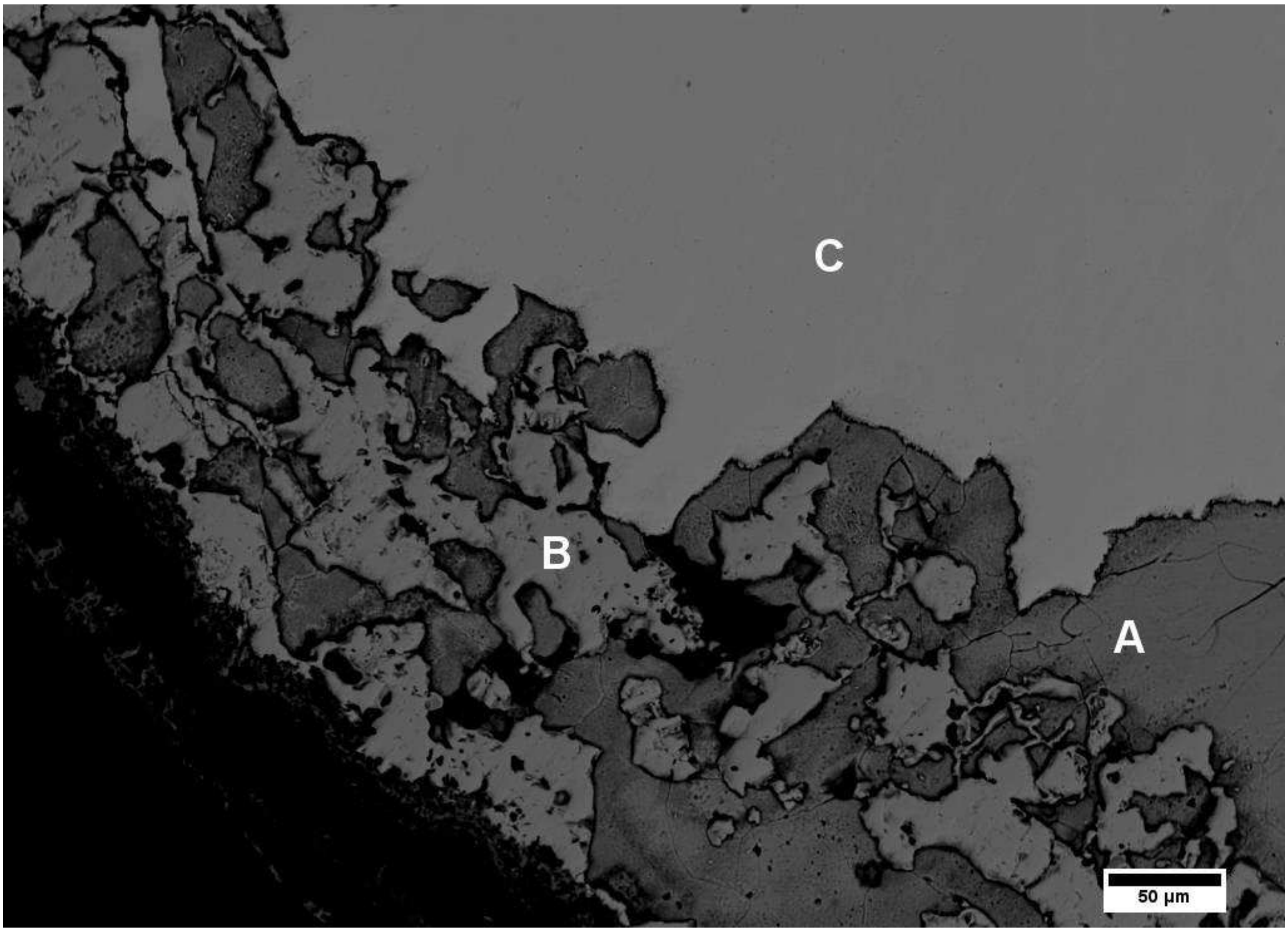

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