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CHAPTER 11: IRON FORGING IN OTTOMAN JAFFA: A METALLOGRAPHIC STUDY OF IRON SLAGS

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Introduction

Iron and steel-making activities in the South Levant have not yet been the object of archaeological studies and profound archaeometric research. Studies carried out so far have mainly been aimed at the analysis of manufactured objects, with an emphasis on earlier ones. Focus was placed on the introduction of the first iron metallurgies rather than on actual technological reflections (Wright 1938; Muhly 1980; Stech-Wheeler et al. 1981; Davis et al. 1985; Muhly 1992). A recent exception is Alexander Veldhuijzen's study of Beth-Shemesh, which, however, still concentrates on the first traces of metallurgical activity (Veldhuijzen and Rehren 2007).

Much of the research aimed at understanding the evolution of techniques and craft organization in this field is yet to begin. Historical texts concerning the subject are not truly useful because they rarely refer to metallurgical activity. This fundamental issue, with its key impact on societies over the centuries, is largely neglected by ancient historians or geographers. Their approach to it remains general and of very limited depth (Bauvais 2008).

Within the limits of our current understandings – that are increasingly confirmed by numerous excavations conducted by the Israel Antiquities Authority – we may note that no reduction activity (primary production of iron from ore) seems to have taken place in the region between the Sinai and the Mediterranean sea in the west to the Jordan Valley in the east, and from Lebanon in the north to the Red Sea in the south. Such has been the case from the time when these techniques were introduced into the Middle East to the present day. This area is consequently dependent on long-distance commercial networks.

This point is vital, because this region has been the theater of numerous military conquests and occupations, which brought with them many technical innovations but also demanded dramatic changes in acquisition networks of the raw material according to geopolitical ties.

This chapter presents analytical data of the iron and steel-making waste exposed at the Qishle excavations. The stratigraphic context in which the metallurgical waste originates dates between the eighteenth and the nineteenth centuries CE. During this period, Palestine was under the political domination and cultural and economic influence of the Ottoman Empire but was also a destination for European traders who viewed it a growing market for Western industrial products.

This situation allowed the meeting of two forms of iron and steel production. On one side, the obtaining of iron by the direct method widely practiced throughout the Ottoman Empire; on the other, the reduction of the ore by the indirect method in blast furnaces, then booming in industrialized Europe (see section below on the reducing processes).

The introduction to the Levantine coast during this period of metal produced by the indirect reduction method raises many questions. How much iron was still produced using the direct process after the influx of the indirect alternative? What was the part played by Ottoman production of iron in Palestine? Did Western industrial production cover major needs in the Levant and at which price? Answers to such questions may prove crucial for our understanding of trade and production during this period.

The Economic Context of Ottoman Metallurgy in Jaffa

Archival material provides us with information on the iron trade in the Ottoman Empire from the sixteenth century. Relatively little data remains regarding the fourteenth and fifteenth centuries, and existing information does not take into account illegal business with the main Italian towns, which defied

the prohibition on iron trade with Islamic nations introduced by Pope Gregory XI (1373 CE).

During the fifteenth century, the western Anatolian region of Bursa appears to have been a zone of production and an export harbor for metallurgical products (Inalcik 1960). Business was conducted mostly with Egypt and Syria via land and maritime commercial routes. The continental route passed through Antalya and served the Levant. Yet the sea route was better adjusted to the iron trade, as it was capable of transporting voluminous and heavy cargoes. As the Turkish historian Halil Inalcik informs us in his work *Fatih Devri*, this was the shorter route; Alexandria could be reached in one week, although safety only improved in 1522, after the Ottoman conquest of Rhodes and Cyprus (Inalcik 1954). The main commercial ports were Aleppo and Alexandria. The port of Jaffa is not mentioned as a direct trade destination from Bursa. In fact, no text refers to any direct dealings with the Palestine coast.

During the eighteenth century, French-dominated international trade made use of southern Syrian ports such as Saïda, Haifa, Acre and Jaffa (Panzac 1990). Annual records by French consuls in the Levant concerning commerce under their jurisdiction contain relatively little information about traded metallic products. Between 1756 and 1787, only manufactured goods such as nails are mentioned as iron artifacts coming from France. Metallic raw materials such as iron bars that were forwarded by the French from Marseille seem to have originated in northern European countries. Therefore, archaeological data resulting from new excavations in Jaffa have undeniable potential in broadening our understanding of production techniques and raw material worked along the southern Levantine coast.

In terms of production techniques, in the fourteenth and fifteenth centuries Europe saw the appearance and the development of indirect ferrous metallurgy in blast furnaces (Fluzin 2004; Dillmann et al. 2007a; Dillmann et al. 2007b).

Very little is known about the introduction of this technique into the Near East. It seems that the only industries of this type were established in the sixteenth century on the coast of the Black Sea (Demirköy-Malki-Samakov), and in southeast of Sofia (Samako) in Ottoman Bulgaria, and operated until the end of the nineteenth century (Danisman 2007: 8). In the beginning of the seventeenth century, 180 blast furnaces were listed in the vicinity of Demirköy (Georgiev 1953). Production here was mainly steered toward the imperial cannon foundries run by imperial decrees and scrupulously monitored by the Ottoman administration. In these early periods very few products of this industry reached the empire's boundaries, even fewer for civilian use. Meanwhile, production in Europe increased enormously. We thus face the question of whether the European markets had the capacity to meet the demands of the Near East.

Prior to presenting this study of the iron and steelmaking waste of the Qishle, we should clarify the mainlines of the "chaîne opératoire" in the iron industry.

The "Chaîne Opératoire" in Iron- and Steel-Making

Physical Properties of Iron/Carbon Alloys

The iron and steel "chaîne opératoire" consists of obtaining and shaping iron/carbon alloys. Steel is an iron/carbon alloy the composition of which is lower than 1.7%. The existence domain of cast iron ranges from 1.7 to 6.67% carbon. The alloy structure changes according to the carbon content. The ferrite is composed of almost pure iron (0.02% carbon), is very flexible and relatively malleable. Cementite is a chemical combination of iron and carbon (Fe_3C) containing 6.67% carbon and the most carburized cast irons. Pearlite is an aggregate of ferrite and cementite containing 0.8% carbon (eutectoid steel). Naturally, there are numerous variations of these combinations between these three states. The increase of the carbon provides the alloy with greater firmness but weaker resistance for mechanical constraints. Iron/carbon alloys containing more than 1% of carbon are very difficult to work and are seldom used.

When the metal is heated, the structure of the material changes and it becomes more malleable and workable. Afterward, when the metal is cooled down in the air, the metal's structure reverts to its previous state called "balance structure." When the cooling condition changes, some other balance structures appear. In the case of steel, their existence depends on the cooling speed of the metal; troostite appears during an average cooling speed, bainite during a higher speed and finally martensite during very high speed. This range of heat treatments (quenching) is at the blacksmith's disposal while transforming the mechanical properties of his alloy.

The Reducing Processes

Since the end of medieval times two different methods have been used to obtain a forgeable mass of metal (Serneels 1998; Fluzin et al. 2000; Fluzin 2001; Fluzin 2004; Mangin 2004; Bauvais 2007; Dillmann et al. 2007a; Dillmann et al. 2007b; Bauvais and Fluzin 2009).

Reduction consists of transforming the iron ore into raw metal combining ore, charcoal and oxygen. In the direct process this operation takes place in temperatures lower than the melting point of the metal in a shaft furnace. The iron and the steel gather in a pasty state whereas the slag produced is liquid. The result of this operation is a mass of iron and/or steel more or less compact (but still having a high proportion of porosities) and containing some slag and charcoal.

In the indirect process, temperatures are higher than the melting point of the metal. It takes place in a draft furnace and produces molten cast-iron that cannot be forged in that state. In order to obtain a forgeable metal, another phase is required, which is the reason this process is qualified as indirect. Cast-iron refining takes place in an open hearth. It is high-temperature controlled oxidation (1100–1300°C) that makes it possible to eliminate carbon from cast iron (decarburization). The result of this phase is very close to a crude mass of iron produced through the direct process. However, the decarburization produces a more homogeneous metal in terms of iron/carbon composition.

The main difference between the two methods is in the temperature of reduction. The direct process produces iron and steel in a pasty state because of a temperature lower than the melting point of the metal, whereas the indirect process reduces the ore at a higher temperature resulting in melted cast iron, which then needs to be decarburized in order to obtain iron or steel.

The following techniques are common to the two processes. Starting with the forgeable crude masses of metal, heating and hammering are applied in order to make them more compact by agglomerating the separate fragments of metal, by welding on themselves the porosities and by evacuating the residual slag. The metal continues to be refined throughout the hammering, from the crude mass of metal up to the finished object, but can nevertheless be stopped. The resulting produce is called 'semi-product'. In principle, the refined product is a semi-product of varying quality.

Then semi-product can be worked (the smithing phase) for the manufacture of artifacts. The craftsman achieves physical and chemical transformations through a wide range of technical gestures and processes. His choices would depend on the raw material (quality, composition), his knowhow and the technical complexity of the aimed object.

Analysis of the Set of Slags

Taphonomical Study and Dating of the Activity at the Qishle

Waste from iron and steel-making activities was distributed in structures and layers dating from the middle of the eighteenth to the end of the nineteenth centuries CE. The contexts included pits, foundation beds of pavements, wall foundation trenches and drainage channels. It should be remembered that this type of waste is frequently reused as ballast or is spread over the ground as a protective drainage layer against excessive rainwater. Thus there need not be a spatial and chronological relation between the discovery context and the workshop in which it was produced. Deeper taphonomical analysis was required in order to shed light on possible post-depositional activity and to narrow the dating range.

Slag remains are very fragile and quickly fragmentize in wet contexts or outdoors, not to mention more destructive environments. Thus only slag-cakes that were rejected and preserved in a stable context could keep their integrity. Complete slag-cakes were discovered in loci 1055 and 1067, which comprise fairly precise chronological contexts. Locus 1055 contained several complete vessels of possible eighteenth-century date, whereas L1067 was under a nineteenth-century floor level. We were thus able to reduce the time frame to exclude the later part of the nineteenth century. The activity therefore seems to have taken place around the turn of the nineteenth century or in its earlier decades.

Archaeometric Study

The analytical protocol applied to this set of slag (Bauvais 2007) takes into account the approaches developed by Philippe Fluzin (Fluzin 1994) and Vincent Serneels (Anderson et al. 2003; Serneels and Perret 2003).

Macrographic Analysis

The first macrographic approach to the set shows that all the waste from this parcel is connected to post iron-ore reduction activity. Thus the iron arrived in this workshop in its metallic shape in order to be worked into objects or into intermediary products (semi-products).

The set of slags amounts to 10.4 kg for 123 pieces, a very small set for this period (Table 11.1). Most of it consisted of whole slag-cakes (57%) and slag-cake fragments (28%). The rest comprised indefinite fragments and formless slags (15%).

A slag-cake has a circular or oval plan and plano-convex section which forms, under the inflow of air, in the warmest point of the forging hearth. Its lower side takes on the concave shape of the stoking hearth (firechamber). The upper side may be concave, flat, and even convex.

A slag-cake results from forging activities carried out between two ignitions of the hearth or between two cleanings of the fireplace, which happens when the smith is hampered during his work by the formation of the slag. If no cleaning appears between two ignitions, a double slag-cake forms with a very well recognizable superposition. Consequently, a slag-cake contains all the elements introduced between a maximum of one day or between these two cleanings.

A formless slag is a small nodule (1–3 cm³) that forms on its own, because of the low quantity of losses during forging (in the case of an activity of low intensity), or on the periphery of a slag-cake and which does not agglomerate to it because the nodule is too far from the slag-cake during its shaping. The simple act of plunging the object or a rabble (the iron bar used in metal industry) into the hearth can separate these fragments of the slag mass when the mass is in a pasty state.

The small size, and fragmentary nature of the formless slags, as well as the peripheral and sporadic conditions that prevail as they are shaping do not make them relevant elements for analysis of the “chaîne opératoire.” Still, their proportions could offer important indications of the intensity of the forging.

The majority of slag-cakes and the small proportion of formless slags found at the site show that forging was sufficiently intense to produce enough waste in the hearth to shape a compact mass. We may conclude that relatively intense production activity was underway here. The average weight of the slag-cakes, 740 gr, confirms this hypothesis and shows that every sequence of activity that took place in the forge between two cleanings produced a significant mass of waste.

The wastes found in the site consist of 51% rusty ferrous slag, 33% clay-sandy slag and 16% dense gray slag. This typology of slag is based on works by Vincent Serneels (Serneels and Perret 2003) and largely corresponds to the proportion of metallic iron and iron oxide compared to silica that the slag contains. The 51% rusty ferrous slag (a type of slag that represents the higher iron content) indicates a significant loss of metal during the work. On the other hand, clay-sandy slag-cakes (a type of slag that represents the lowest iron content) comprise a category of very homogeneous waste that reflects significant siliceous addition during certain working phases.

Because it is necessary to bring the metal to high temperature in order to forge it and because the fireplace is open, the atmosphere reigning in such a hearth is strongly oxidizing. The atmosphere is all the more oxidizing as the temperature is high. That is why during welding activities which need a temperature of at least 1200°C it is all the more necessary to use a protective addition on the surface of the metal to prevent it from oxidizing. This practice of protective addition also occurs during finishing activities, when the surfaces of the worked object are the most fragile.

Three groups of slag-cakes can be distinguished based on their morphology and composition (Table 11.2). *Group 1.* Very heavy slag-cakes (from 1020 to 1500 gr), reacting strongly to the magnet testing. Their upper surface is strongly oxidized and granular. Their shape is concave, except in the case of sample 008 in which the trough is filled with an accumulation of “drops.” Their lower surface is oxidized and they assume the shape of a regular and granular curvature, taking the imprint of the layer of charcoal on which they formed. They are gray, beige and rust in color.

Group 2. This group is characterized by an exclusively clay-sandy composition. The average mass of the slag-cakes is reduced (from 318 to 519 g) to a volume equivalent to that of other groups. They are not reactive to a magnet and they contain limestone inclusions. Their upper surface is clay-sandy, very porous and the numerous bulges seem to be the result of internal degassing. Their lower surface is also clay-sandy, porous and bulbous. Their general color varies from beige to white, with some greenish tints.

Group 3. This group includes the only slag-cake distinguished from the others by its morphology. It is

of low weight for the set (584 g) and reacts to a magnet. Its upper surface is flat, porous and very hydro-oxidized. Its lower surface is regular, granular and also hydro-oxidized. It is gray, rust and green in color.

According to the first macrographic analysis this set of slags represents a whole coherent succession of activities. These three groups of forging slag-cakes correspond to various stages of the “chaîne opératoire” from intensive and coarse work to a practice linked to the finishing of objects. This succession of activities and the very small quantity of slags that were found (little more than 10 kg) tends all the more to support the same chronology.

Metallographic Analysis

This method processes the theoretical and practical rules of the thermodynamics, in order to understand the formation conditions of the elements analyzed (metal, slag). The aim is to bring to light what takes place at the site between the reduction and the elaboration of an object. Presence or absence of each of the indications is noted and it is their combinations and convergences (on the whole object and not on a sample) that will allow us to build hypotheses of interpretation. We shall not present here the various characteristic indications of every phase, but rather refer the reader to the rich literature on the subject (Mangin *et al.* 2000; Leroy 1997; Fluzin 2004; Mangin 2004; Senn-Bischofberger 2005).¹

The sampling was done on the complete slag-cakes, in light of the valuable potential information that this type of waste may supply (Figure 11.1). Two samples from Group 1 were analyzed so as to confirm their association with the same work phase. Only one sample from Group 2 was selected, as the slag-cakes of this group were particularly homogeneous. The slag-cake from Group 3 was also analyzed.

Group 1 slag-cakes showed strong resemblance, linking them to the same working sequence (INV 002 and 008). Sections revealed a composition of 15–20% and 45% of metal in the form of stratified layers. The bottom consists of a juxtaposition of metallic grains or metallic surface separated by slag. Toward the surface the metal becomes compact and forms homogeneous masses (Figure 11.2). The silicated matrix of the samples is fayalitic in nature, with very small slats. The absence of visible iron oxide in the matrix is most striking in these slags, with no wüstite present. When the metal becomes denser it is characterized by porosities and by numerous folding. The metal composed of very well formed and equiax ferrite grains (0.02% C).

The section of the slag-cake INV 007 (Group 2) revealed a thoroughly clay-sandy composition with a very strong porosity proportion (around 70%). In some places, fragments of limestone are visible and we also recognized a fragment of shell in its right side (Figure 11.2).

Unlike the clay-sandy parts at the top of the section, the more homogeneous areas of amorphous silicate and of crystallized fayalite with very small cobbles in some of the lower parts reveal a temperature that allowed partial liquefaction of the clay-sandy material. These parts contain small concentrations of metallic prills that show more significant losses in the beginning of the activity (lower part), than a decrease of the losses influenced by the use of additives (higher part). No trace of wüstite or other iron oxides are detectable.

¹ Analytical protocol:

- Macrographic photos of all the faces of the selected samples
- Sawing into sections under lubricating
- Photography of one or several cutting surfaces
- Coating with an appropriate heat-hardening resin
- Mechanical polishing under lubricant up to a granularity of 1µm
- Photography of the polished surface
- Complete observation under metallographic microscope (magnification from 25 to 1000)
- Etching with Nital (3% nitric acid in alcohol)
- New complete observation with microscope
- Drawing of the cutting surface

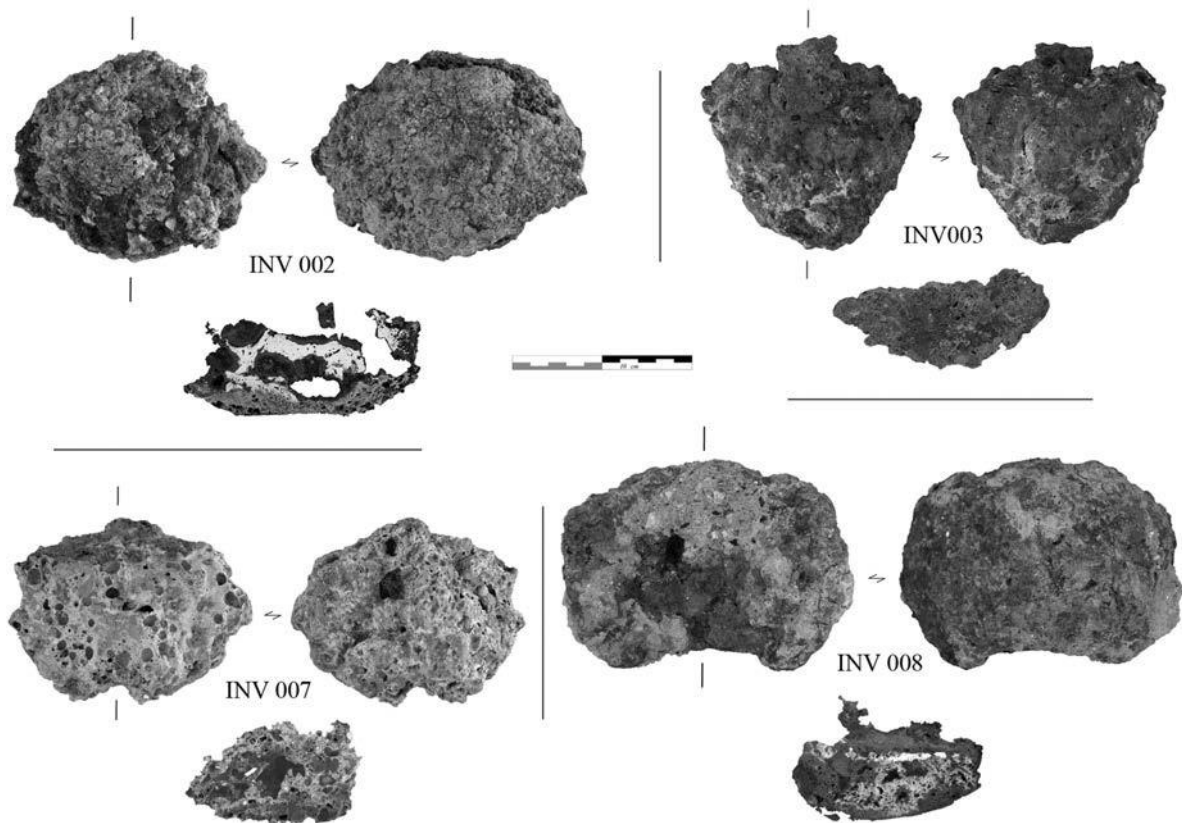


Fig. 11.1. Presentation of the four slag-cakes sampled: for each, upside, underside and cutting surface.

The section of INV 003 (Group 3) shows a completely corroded surface. Areas which could correspond to metallic fragments adjoin corroded zones, as do areas which appear to have been former zones of porosity (Figure 11.2).

The level of corrosion makes a chemical and microscopic analysis of this slag-cake problematic. However, flat hammer-scale is present in amorphous areas protected from the corrosion.

Only few metallic zones were protected in the center of the initial fragments. On the periphery of what seems to have been a former fragment of metal, a layer of wüstite appears to indicate a peripheral hot-oxidation. A zone also seems to show a ghost-structure of steel (Wildmanstätten structure – 0.4% of C).

It is difficult to extrapolate much information from this slag due to the high levels of corrosion. However, the peripheral hot-oxidation of the metallic fragments indicates a forging phase in an oxidizing atmosphere. This impression is confirmed by the presence of flat hammer-scales in the matrix.

Synthesis and Interpretation

The Techniques Used

The most significant aspect in this set of slags is the complete absence of iron oxide losses in the Group 1, while much metallic iron is present. During a refining phase (whether it is a mass from direct or indirect process), a large quantity of metallic losses is present, but the forging context and the volume of the mass dictated work mostly in oxidizing atmosphere. Thus, the proportion of iron oxide losses is also high. Yet during forging activity, the majority of losses occur in the shape of oxide (drops, hammer-scales) and more rarely in the shape of fragments and metal prills. Compared to the quantity of metallic losses, iron oxide losses are indeed too weak to have come from a usual refining or elaboration working phase. To have come from such a phase, these activities would have had to take place in a reducing atmosphere. For the same reason, it is impossible to explain the strong metallic quantity of losses by calling upon a practice of cast-iron refining even regarding the exclusive presence of ferrite. Another possibility is that Group 1 represents high-temperature recycling activity (1300–1400°C), leading to the

agglomeration of fragments of metal in a forging hearth covered with charcoal in order to preserve a reducing atmosphere. The product of this technique would be close to a crude mass of iron. Slag-cakes analyzed from Group 1 would then be the lower part of the metallic mass that forms in the forging hearth. A part of the metal would have remained trapped in the bottom whereas a more compact metallic mass would have been produced above.

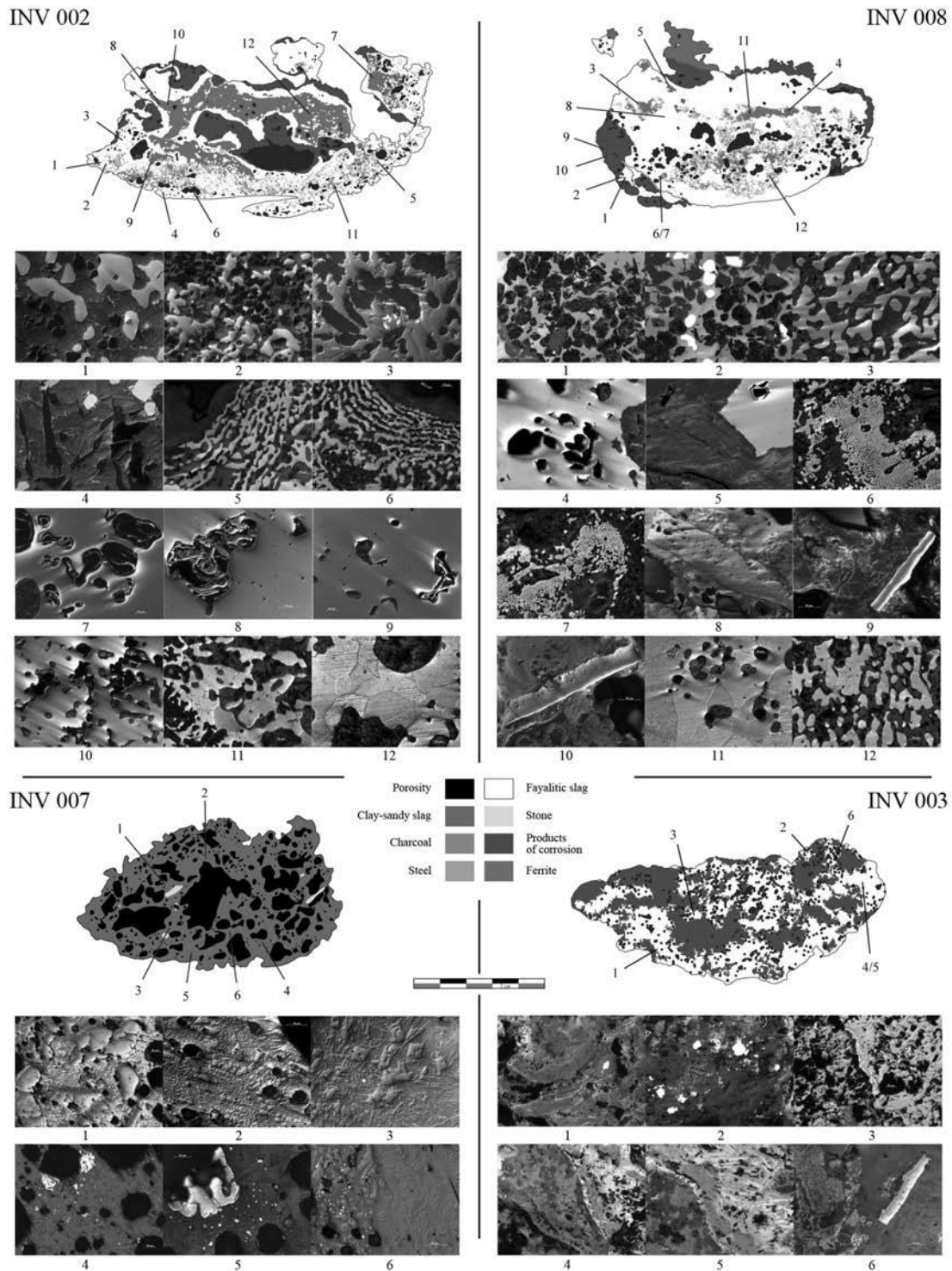


Fig. 11.2. Results of the metallographic analyses of the four samples: schematic drawings of the analyzed surfaces and localization of the micrographs.

Group 2 is characterized by a large quantity of clay-sandy additions. It comprises a significant amount with quasi-absence of metallic losses and very few losses of oxide. Massive use of sand or clay is a

common means for the protection of a piece against hot-oxidizing during the finishing-phases. Based on blunt angles of silica grains and the presence of fragments of shell in sample 007, the protective material appears to be marine sand.

What we seem to have here reveals not only production of metal mass (whether from recycling, refining of crude mass or refining of cast-iron) but also object-finishing activities. The stage of full forge is missing between these two work phases. Sample 003, from the third group, could correspond to this activity but strong corrosion denies us details necessary to corroborate this interpretation.

The presence of coal fragments in the samples' periphery indicates that at least a part of the fuel required for production was mineral coal.

The Worked Metal

Only fragments and ferritic zones were present in the slag-cake assemblage at the Qishle and no metallic scraps (fragments of objects, waste of manufacturing, discarded items due to production failure) were discovered. The absence of hot-oxidation, and thus of decarburization, could mean nonetheless that the worked metal is mainly soft iron. A posterior technique of case-hardening (carburization) would be necessary to make the products useful (steel), yet no indication for this was discovered.

The Products

New masses of metal clearly emerged from the first phases of activity. Does this indicate the manufacture of a product intended for trade, which would make it part of the final production in this workshop? Or simply the unfinished product of an intermediate phase, which still demanded further work? What seems certain is that the metal produced is low-carburized iron, which may provide us with information about the possible resulting product. In any case, carburizing was a well-mastered, common practice in this period, sufficient for the manufacture of steel that could be used in making other products.

The use of clay-sandy additions in great quantities (sufficient to form large-sized clay-sandy slag-cakes) may mean that products needed to be well protected from hot oxidation during the finishing phases. It could indicate the production of well-made objects of small size.

Conclusion

This is the first research to be carried out with regard to iron and steel making techniques used on the Levantine coast during the Ottoman period. The present hypotheses will need to be consolidated by more analysis and especially by more experiments. Such experiments should provide a comparative database for scrap-recycling techniques and the waste that they produce.

Our interpretations from the above study indicate that the workshop discovered in the Qishle site was used to recycle metal scraps. Referring to E. Ashtor's (Ashtor 1972; Ashtor 1975) studies on the profits of the European trade of iron with the East in the fifteenth century, this metal would have been rather rare in the region, explaining the importance of such production. Indeed, taking into account taxes and transport cost, European traders would enjoy an approximate profit of 300%. Although the Ottomans had set up steel-making regions (where the indirect process was employed) in Bulgaria and Anatolia beginning in the seventeenth century, the channeling of these materials to markets met with the same difficulties as those coming from Southwest Europe (Italy, France, Spain). Furthermore, despite a high production rate, these regions did not meet the full needs of the Ottoman Empire, as a good deal of the metal produced was intended for the imperial cannon foundries. The price of metal intended for ordinary activities would not have changed considerably between the fifteenth and the nineteenth centuries (Sprandel 1970), because even if Europe had significantly increased its production, the general demand for this material increased just as much.

Table 11.1: Inventory of slags classified by provenance and category.

Locus	Basket	Square	Category	Subcategory	Number	Weight (kg)
146	1795	A11	Slag-cakes		1	0.519
949	10217	A34	Slag-cakes		1	0.354
1002	10529	A31	Slag-cakes		1	0.375
1008	10516	A34	Slag-cakes		1	0.316
1055	10691	A33	Slag-cakes		1	1.5
1067	10839	A30	Slag-cakes		2	1.604
1069	10776	A52	Slag-cakes		1	1.29
114	1609	A14	Frgt of slag-cakes		1	0.064
133	1707	A14	Frgt of slag-cakes		1	0.079
133	1707	A14	Frgt of slag-cakes		1	0.075
137	1740	A20	Frgt of slag-cakes		1	0.13
154	1835	A18	Frgt of slag-cakes		24	1.2
813	9534	A16	Frgt of slag-cakes		1	0.109
950	10221	A37	Frgt of slag-cakes		1	0.149
997	10448	A34	Frgt of slag-cakes		1	0.458
1008	10602	A34	Frgt of slag-cakes		2	0.075
1008	10516	A34	Frgt of slag-cakes		7	0.058
1055	10719	A33	Frgt of slag-cakes		4	0.101
1055	10691	A33	Frgt of slag-cakes		2	0.367
154	1835	A18	Formless slags	Flowed	4	0.05
154	1835	A18	Formless slags	Plate-shaped	3	0.103
154	1835	A18	Formless slags		1	0.006
154	1835	A18	Formless slags	Magnetic	2	0.11
158	2078	A18	Formless slags		3	0.34
949	10217	A34	Formless slags		3	0.073
949	10312	A34	Formless slags		10	0.204
949	10251	A34	Formless slags		6	0.078
988	10406	A34	Formless slags		17	0.083
997	10448	A34	Formless slags		10	0.102
1055	10691	A33	Formless slags	Magnetic	1	0.087
111	1607	A16	Formless slags		2	0.027
146	1795	A11	Formless slags	Flowed	7	0.286
				Total	123	10.372

Table 11.2: Inventory of slag-cakes classified by groups.

Group	Locus / Basket	Inv. N°	Length (cm)	Width (cm)	Thick. (cm)	Weight (g)
1	L.1069 / B.10776	002	11	11	8	1290
1	L.1067 / B.10839	004	9.9	14.8	9.5	1020
1	L.1055 / B.10691	008	10.2	14.3	6.3	1500
2	L.146 / B.1795	001	9.5	12.5	7.9	519
2	L.1002 / B.10529	005	10.1	11.3	6.1	375
2	L.1008 / B.10516	006	11.1	11.3	4.8	318
2	L.949 / B.10217	007	9.1	12.2	6.1	354
3	L.1067 / B.10839	003	10.8	10.1	5.5	584

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