Foundation for Science Technology and Civilisation

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Release Date: May, 2007
Publication ID: 701

FSTC Limited
27 Turner Street, Manchester, M4 1DY, United Kingdom
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OTTOMAN MINING AND METAL WORKING IN THE BALKANS: ITS IMPACT ON FIRE-ARMS TECHNOLOGY OF SOUTHEAST EUROPE (15TH -17TH CENTURIES)

Prof. H.H. Günhan Danisman*

The article is originally a talk presented at the international conference *1001 Inventions: Discover the Muslim Heritage in our World* held at the Museum of Science and Industry in Manchester on the 8th of March 2006, on the occasion of the launch of the exhibition 1001 inventions. The conference proceedings are edited by Dr. Salim Ayduz and Dr. Saleema Kauser.

Background

From the point of view of early history of metal technology, the Near East and particularly Anatolia had a unique role as the earliest centre for the discovery and utilization of copper ores. Increasingly available archaeo-metallurgical evidence from various sites in Turkey indicates that mining and metallurgy started here around 9,000 BCE.[1] Geologically there is clear indication that Anatolia had an abundance of several metal ores, besides copper oxides, such as iron, arsenic, antimony, lead, silver, gold and zinc. A large number of archaeological excavation reports from the Balkans region also point towards the fact that the metal working spread to other regions from Anatolia, following the northward retreat of the glaciers from the Fourth Ice Age. The two straits between Asia Minor and Thrace, the Bosphorus and the Dardanelles have acted as natural bridges or crossing points for the diffusion of knowledge of metallurgy into the Central and the Western Europe. There is abundant data revealing that firstly the copper smelting, later the arsenic and then tin-bronze alloying, and finally iron extraction had spread into the Eastern and the Central Europe during Bronze and Iron Ages.

Field research by the Department of Archaeology of the Istanbul University since early 1980s has provided evidence for Demirköy-Samakocuk and its vicinity in northwest region of the Turkish Thrace as an important mining and metal working centre in antiquity (Figure 1).[2] In addition to this, archival sources indicate increased importance of the region during the rise of the Ottoman State receiving special privileges in line with similar strategic considerations.[3] The Ottoman supremacy in the Balkans Region starting from

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The industrial archaeology surface surveys and excavations conducted under the auspices of the Society of History of Turkish Science at an Ottoman iron working area consisting of foundries, furnaces, mining galleries, and water power systems at Turkish Thrace, incorporate the participation of the Museum at Kırklareli, six Turkish Universities, as well as the Metallurgy Museum at Bochum, Germany. The Project is being generously supported by grants from the Turkish Prime Ministry's Public Relations Fund, the Dössim Fund of the Turkish Ministry of Culture and Tourism, the "Social Sciences Fund" of the Turkish Scientific and Technological Research Society (TÜBİTAK), as well as the Scientific Research Projects Fund of the Boğaziçi University through Project N° 04-B-904.

[1] For a recent and most-up-to-date summary of Anatolian copper mining and copper working, see: Bilgi, Ö., Özbal, H. & Yalçın, Ü., "Castings of Copper-Bronze", *Anatolia: Cradle of Castings*, ed. Önder Bilgi, Grapho Printing (Döktaş), Istanbul, 2004, pp. 2-44.
[2] Özdoğan, M. & Yalçın, Ü., *Dereköy-Şükrüpaşa Yüzey Araştırması*, Unpublished Survey, 2001 (verbal communication).
[3] Uçan, L., *Trade Relations of Ottoman Kırklareli with the Sublime Porte in the 19th Century*, Unpublished M.A. Thesis, Boğaziçi University,

the early part of the 14th century onwards had been a simultaneous development with the introduction and development of the use of fire-arms technology in this region.

Figure 1. Map of Demirköy iron working area.

The early Ottoman enthusiasm for fire-arms technology

Arab armies penetrated into Central Asia from the beginning of 8th century onwards, and the nomadic Turkish tribes began to accept the Islamic faith gradually. The Turks had a reputation as good soldiers, and from the second half of the 9th century, they began to replace the Persian soldiers serving under the Abbasid Caliph of Baghdad. Within a short time, Turkish officers rose to be commanders of the Abbasid armies, and began to establish independent states, firstly in Egypt at the beginning of the 10th century under Ahmed bin Tulun, and then in the east up to the Indus Valley under the name of Gaznevid State by the first half of the 11th century. To the further north, the Karakhanids founded the first truly Turko-Islamic state by uniting the Turkoman tribes in Transoxiana, while the west of the Karakhanids' territory were the Oghuz Turks, from whom the Great Seljuks in the 11th century and the Anatolian Seljuks in the 12th century were descended.[4]

As the Seljuk power over Anatolia weakened under the Mongol invasions during the 13th century, and finally succumbed completely to the İlkhanid Mongol rule, a new wave of Turkoman tribes began to penetrate into central Anatolia pushed out of their central Asian homelands by the onslaught of the Mongols. By the end of the century, one of these tribes, the people of the Kayı Tribe belonging to the Oghuz Turks, as well, had settled into the territory between the towns of Söğüt and Bilecik on the borders of the contracting Byzantine State. Soon after, these people assumed the name of their first ruler who declared his independence from the Seljuk sovereignty, Osman Ghazi.

Istanbul, 2002.
[4] Claude C., *Pre-Ottoman Turkey*, London, Dublin, New York, 1968, pp. 20f.

Both the Seljuk and the Ottoman Turks had the advantage of acting as the intermediaries, together with the other nomadic peoples of the Central Asian plains, for the transmission of technology between China and the Western World, including the compass and the gunpowder. By the middle of the 1300s, when the Ottomans were able to control Asia Minor, and had crossed the Dardanelles and started to expand towards Europe, they were already familiar with numerous uses of the gunpowder and were now starting to get to know the first primitive fire-arms that the Europeans were experimenting with during the first half of the 14th century.

Ottoman Turks reached the Marmara Sea shores in 1321, they crossed into Europe in 1349, and they were on the shores of the Adriatic Sea in 1371. The Ottoman rulers had a remarkable and persistent enthusiasm in developing more advanced fire-arms. Sultan Murat I's victory at the first Kosovo Battle was dated 1389, during which he used cannons against the Serbs,[5] while his son Beyazit I (the Thunderbolt) entered Athens in 1397 with the unarguable assistance of his superior mobile artillery forces. The Ottoman historical sources mention that they had used bronze cannons in 1354 and 1358, and cast an iron cannon in Bursa in 1364, employing it against the Karamanid army the same year.[6] The major breakthrough in fire-arms technology, however, came at the middle of the 15th century, when Sultan Mehmet II (the Conqueror) laid the city of Constantinople under siege and captured it on 29th May 1453. Having acquired on very generous terms the services of an otherwise very frustrated bronze cannon casting expert of Hungarian stock named Urban, whose knowledge of producing large bronze church bells was instrumental in producing for the Sultan the famous *shahee* cannons (Figure 2), which were also known by his name "Muhammed" and were longer than seven meters with a bore of 88 centimetres that could fire granite balls weighed in the range of 270 to 400 kilograms, causing pregnant women to have miscarriages when fired with huge booming noise.[7] Thus, the first impressive weapon of the age of gunpowder was realized. This achievement of the Ottoman Turks and the skill of the succeeding generations of the Turkish cannon founders spread the knowledge of heavy mobile artillery from one end of Europe through India of the Mogul Emperors to the Island of Sumatra by the end of the 16th century.

[5] Aydüz, S., *Osmanlı Devleti'nde Tophâne-i Amire'nin Faaliyetleri ve Top Döküm Teknolojisi (XIV-XVI. Asırlarda)*, Unpublished Ph.D. Thesis, İstanbul University, 1998, pp. 21f.
[6] Ibid., p. 22.
[7] Crosby, A.W., *Throwing Fire, Projectile Technology Through History*, Cambridge University Press, 2003, p. 104 ff; al-Hassan, A.Y. & Hill, D.R., *Islamic Technology*, Cambridge University Press / UNESCO, 1986, p. 115.

Figure 2. Sultan's Mehmet II's Shahee canon.

The manner by which Urban was able to cast these huge bronze cannons has led to numerous speculations on the technology that lay behind their production, due to the jealously guarded trade secrets at the time. One recent and a more reliable account was suggested in a fictional reconstruction of Urban's efforts by a Turkish metallurgical engineer, whose proposal of a vertical casting technique into an initially prepared clay-earth mould within the ground that is later carved out in the shape of the shahee cannon with a steel auger, into which a specially prepared spade and porte head were lowered to create muzzle vent and then molten metal was poured from a highly advanced bronze furnace seems very close to reality,8 and needs to be further determined through archival and archaeological research.

Ottoman capacity for large scale industrial iron production

In 1991 the newly established Directorate of Kırklareli Museum in Turkish Thrace identified and registered as an "archaeological conservation area" the remains of around 10,000 meter square of an Ottoman iron foundry situated 4 kilometres east of the town of Demirköy (meaning "Iron Village" in Turkish) in the middle of a heavily forested region of the Istranca massifs (Figure 3).

[8] Çıracıoğlu, V., *Kara Büyülü Uyku*, İlhaki Yayınları, Istanbul, 1999.

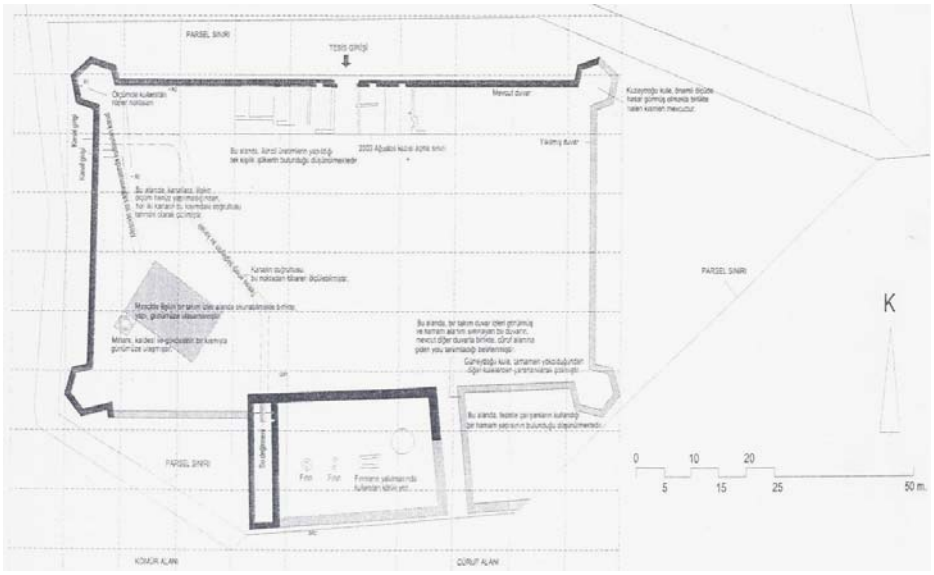

Figure 3. Demirköy-Samakovcuk iron foundry restitution (scale 1:500).

Known as "Samakocuk" from the Ottoman archival documents, the town lies approximately 25 kilometres east of the Bulgarian border and about 20 kilometres south of the Black Sea shore. In June 2001 the Museum Directorate had carried out a preliminary salvage operation at the foundry involving surface cleaning from thick growth of bushes and trees, and the construction of a protective perimeter fence around the cleared site.[9] Since May 2002, a multi-disciplinary and a multi-institutional project has been initiated under the auspices of the Society for the History of Turkish Science, for the purposes of conducting a comprehensive research on iron mining and iron working in the area, and starting from the summer season of 2003 surface surveys, excavations and archival investigations have been carried out (Figure 4).[10]

[9] Yılmaz, Z., "Demirköy (Fatih) Dökümhanesi (kazı, Temizlik ve Çevre Düzenlemeleri Çalışmaları)", *13. Müze Çalışmaları ve Kurtarma Kazıları Sempozyumu*, (22-26 Nisan 2002-Denizli), T.C. Kültür Bakanlığı, Anıtlar ve Müzeler Genel Müdürlüğü Yayını, Ankara, 2003, pp. 29-42.

[10] The Project Team for the summer season of 2005 field research was composed of the following members (Figure 6):
Project Director: Prof. Dr. Ekmeleddin İhsanoğlu, President of the Society for the History of Turkish Science;
Director of Excavations: Archaeologist Zülküf Yılmaz, M.A., Director of Kırklareli Museum;
Rescue Archaeology Team: Prof. Dr. Ali Osman Uysal and the faculty members and students of the Dept. of Art History at the 18th March University of Çanakkale (the Dardannels);
Industrial Archaeology Team: Prof. Dr. Hadi Özbal of the Chemistry Dept. of Boğaziçi University, Prof. Dr. Günhan Danışman of the History Dept. of Boğaziçi University, Assoc. Prof. Dr. Ünsal Yalçın and Dr. Guntram Gussman of the Metallurgy Museum at Bochum, Germany, and the faculty members and students of the Dept. of Art History of the Anatolian University at Eskişehir;
Geodesic Survey Team: Asst. Prof. Dr. Gülsün Tanyeli, Dr. Kani Kuzucular and the graduate students of the Restoration Dept. of the Faculty of Architecture of the İstanbul Technical University;
Archival Research Team: Assoc. Prof. Dr. Mustafa Kaçar of the Dept. of History of Science of İstanbul University and Prof. Dr. Attila Bir of the Engineering Faculty of the İstanbul Technical University.

Figure 4. Excavations at the fortified settlement and Masjid.

The foundry site has been relatively well preserved due to its inaccessibility and its thick covering of vegetation, in spite of large amounts of stone masonry and tons of slag heaps removed by military units in the region and the Forestry Commission for construction and road building purposes during 1950s and 1960s. The foundry is composed of two separate terraces, an upper residential terrace within rectangular fortification walls and polygonal corner towers, and a lower terrace about 7 or 8 meters below containing the foundry itself. Senior citizens in the vicinity have testified in oral history interviews that the perimeter walls were approximately 4 meters high as recently as 1950s. During the first two seasons of excavations at the upper terrace, it was revealed that not only living quarters, but also barracks for a substantial military contingent was stationed here for the security of the site and its production within a hostile forest environment, particularly during the late 18th century and later in 19th century when banditry was rampant along the Istranca Mountains as the central authority of the Ottoman administration deteriorated. At the upper terrace there is also a mosque, the minaret of which is still standing. Remains of partially intact stone-built canals carrying water diverted from a nearby stream for the operation of at least two water wheels within the foundry have been discovered.

Figure 5. View of the iron furnace from east to west.

At the lower terrace, in addition to two well preserved high furnaces (Figure 5), remains of water canals and supporting structures of the water wheels, probable location of cam operated bellows, a circular base for heavy hammer and anvil, as well as large heaps of slag and charcoal were recorded. The initial results of investigations within the fortified settlement following three seasons of excavations indicate that two large single storey residential type blocks rest against the fortification walls, and based on pottery and small finds evidence, the earliest remains in this portion date back to the 18th century. It is also clear that the site may have been enlarged towards the north sometime in the 19th century by moving the perimeter wall at least 6 to 7 meters. Furthermore, archival research done by Assoc. Prof. Dr. Mustafa Kaçar of the Chair of History of Science at Istanbul University suggests that the foundry had undergone a major revival during the reign of Sultan Mahmud II (1808-1839), and it has sustained several severe fires, after which repair and restoration works were carried out in order to continue iron production until the end of the century.[11]

Figure 6. Members of the field research for the summer season of 2005 besides furnace remains in the forest.

During the summer season of 2005, in addition to the excavations at the upper residential terrace which were continued for the third year, the industrial archaeology team carried out a sounding expedition at the location of two furnace mouths hidden under a thick forest cover, that were located about 250 meters west of the original foundry site, in order to investigate the type of furnace technology.[12] The three weeks of excavation here surprisingly revealed a second foundry site. As the work progressed, a rectangular workshop measuring 20 meters by 50 meters and divided into two sections with a central entrance hall was unearthed. It also became clear that the same system of dikes and water canals serviced both foundries for the operation of the water wheels supplying energy for the bellows, as well as the trip hammers for the

[11] Name of Document: *Imperial Decree*, No. 585-28759, dated Hicri 1245: "cannon balls produced at Samakocuk factory… and cast under the supervision of former Samakocuk superintendents contain flaws… and are not to the standard; thus, they become useless in case of necessity, and also because the said factory has burnt down, from now on if the helon (cast iron ingots?) and charcoal shall be procured from Samakocuk and casting will be done in Istanbul…"

[12] Under the coordination of the Directorate of Kırklareli Museum, Prof. Dr. Hadi özbal and Prof. Dr. Günhan Danışman cooperated with Assoc. Prof. Dr. Ünsal Yalçın and Dr. Guntram Gassman of the Metallurgy Museum at Bochum (Germany), during the month of August 2005, for this second stage of operations. The geodesy work was organized by the Chair of Restoration of the Faculty of Architecture at Istanbul Technical University, under the direction of Asst. Prof. Dr. Gülsün Tanyeli. The excavation team of ten strong consisted of the young faculty members and students of the Department of Art history at Anatolia University in Eskişehir, led by Inst. Abdullah Deveci of the University's Department of Architecture.

wrought iron production. One of the furnaces excavated within the eastern workshop of this new foundry turned out to be a shaft (or bloom) furnace for iron (Figure 7 a-b) production illustrating an advance 17th century technology. In the middle of the west wing of this new foundry was identified a copper smelting furnace. Archival documents related to the Ottoman financial records dated to the 19th century indicate that copper was the second important metal produced at Demirköy-Samakocuk foundries besides iron production, and that the raw copper was used for making copper alloy moulds for cannon balls for the Ottoman artillery forces.[13]

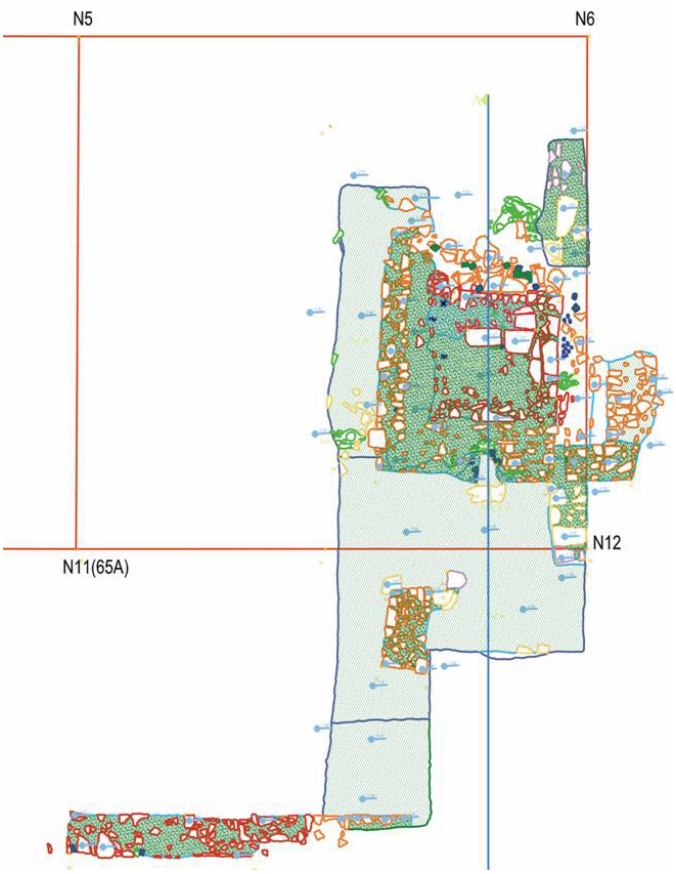

Figure 7-a. Plan drawings of the iron furnace.

[13] Name of Document: *Imperial Decree*, No. 585-28771, dated Hicri 1250: "One piece of formal letter from the accountant of the Royal mint; as would be understood from its contents, the cannon balls and shells which are arranged from Samakocuk foundry for the Royal Cannon Foundry and the Royal Arsenal and for the Bomb-shells Foundry to be cast from pure metal as clean and polished is part of the procedure and the regulation. Therefore, this circumstances require that the moulds should be renewed once every week, thus the required 10 thousand *vakiyye* raw copper be delivered from the Royal Mint has been communicated and favoured by His Excellency the Illustrious Damat Pasha…"

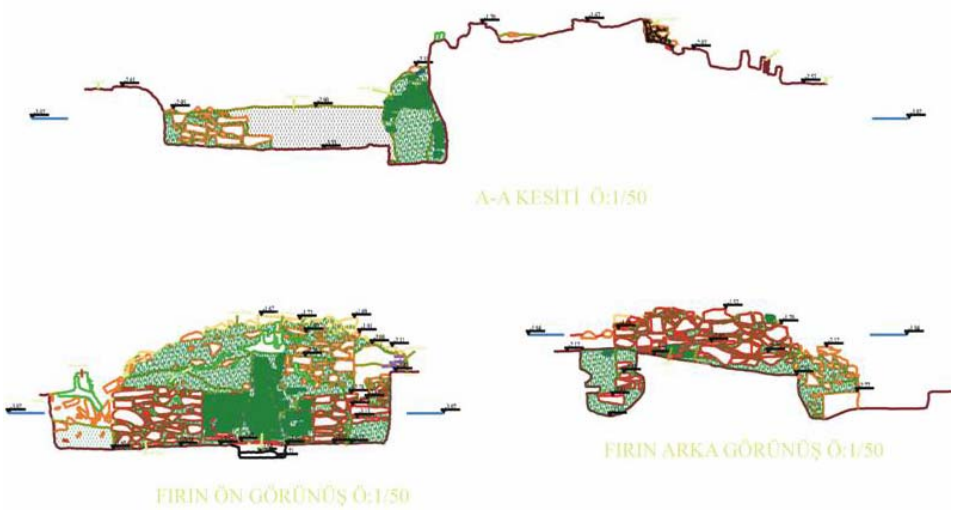

Figure 7-b. Section drawings of the iron furnace.

What is more spectacular is the evidence discovered for the Ottoman capacity for large scale industrial iron production at Samakocuk. Since the summer season of 2003, a team of experts from three Turkish Universities, i.e. Boğaziçi, Istanbul Technical and Anatolia universities, as well as Dr. Ünsal Yalçın from the Metallurgy Museum at Bochum, Germany, have been conducting simultaneous archaeo-metallurgical surface surveys within the thickly forested area in the vicinity of the foundry. An area measuring approximately 30 kilometres square has been systematically researched revealing huge slag deposits, abandoned mine galleries, remains of high furnaces as well as a complex system of water canals, dams and sluices along the streams. The surface finds have been recorded on a map of the region of 1:25,000 scale using GPS instruments, and samples from slags, ores and metal scraps are being currently analyzed at the archaeometry laboratories of Boğaziçi University. The overwhelming richness of the available evidence indicates that the duration and the production amounts must have been extensive through various periods of this region's metal working history. A Bulgarian reference dated 1614 had listed over 180 shaft furnaces in working order around Malki Samakov (i.e. Demirköy-Samakocuk).[14] This number alone indicated a very substantial level of industrial organization and sophisticated technology for iron production for the 17th century.

Preliminary conclusions

As Ottoman iron production developed into a major industry from the beginning of the 16th century onwards, two more foundries had become operational in addition to Demirköy-Samakocuk foundry; one at Samako situated about 60 km southeast of Sofia and the other one at Pravişte, probably located at the juncture of the present day borders of Greece, Bulgaria and Turkey.[15] As more detailed information is being available from the Ottoman archives, it is becoming clear that the Ottoman authorities organized the

[14] Görgiyev, G.K., *Mining in Southwest Bulgaria and Southeast Macedonia*, Bulgarian Academy of Sciences, Sofia, 1953, p. 24.
[15] Name of Document: *Imperial Decree*, 586-28820, dated Hicri 1255: "As your Highness remembers, the monthly salaries of the trainer summoned from England by written instruction in order to be employed at Samakocuk, Pravişte and Samako factories, and of the engineer and the translator that accompany him shall be extracted from the said provinces as ordered by the Sultan…"

subcontracting of iron mining and iron smelting to the local populations and individual entrepreneurs.[16] The bloom iron thus produced was then being purchased by the local foundry administrators, who in turn either realized second stage iron production through various finery processes, or shipped the raw iron to Istanbul for the requirements of the Imperial Cannon Foundry, or Imperial Arsenal, or else the Imperial Bomb-Shells Factory. The archaeo-metallurgical analysis which is progressing at the laboratories of Boğaziçi University and at Bochum Metallurgy Museum has started to indicate that almost all types of secondary processes were being employed at Demirköy-Samakocuk foundries. C14 dating of charcoal pieces remaining within the slag samples is expected to give reliable chronological data for many of these processes, as well. It is, therefore, quite evident that at the height of the iron production during the 17th century prior to the introduction of modern methods of steel production in Europe, the Ottomans have put into practice a unique system of "private-public partnership" in industrial metallurgy in the Balkans, far in advance of other parts of the Continent. It is expected that the foundry will be restored and turned into an open-air industrial archaeology museum in working order, following the completion of the research project, probably soon after the year of 2010.

[16] Name of Document: *Imperial Decree*, No. 585-28779, dated Hicri 1254: "For the cannonballs and shells produced at Samakocuk Foundry, upon fixing of the price of one bushel of ore that is being purchased from the *reaya* (Christian) subjects who are miners *(cevherkeş)*, the above-mentioned subjects have submitted petitions and requested favours, and consequently they have been granted 20 *para* (=1:40 *kuruş* or piaster) additional for each scale…"