

ARCHAIC ORE MELTING FURNACES OF EXCEPTIONAL HISTORICAL VALUE, WHICH WERE USED IN THE CARPATHIAN-DANUBIAN SPACE. TECHNICAL, HISTORICAL, EPISTEMOLOGICAL, METHODOLOGICAL, MUSEOLOGICAL AND AXIOLOGICAL ASPECTS

Liviu Alexandru Sofonea

University of Brasov, ROMANIA

Summary: The paper describe and analyses a few archaic furnaces discovered near the mining centre of Ghelari, district of Hunedoara, Romania, which were used by technicians for a long time to melt iron ores. The oldest furnace was built in the Middle Ages.

Key words: archaic ore melting furnaces, Romania.

The ore melting furnace* (iron and others) from the Early Middle Ages

The characteristics of the technically remarkable artefact, $A^{\text{Tech.}} = C_{\text{H.I.}}^{\text{melt.ores.}}$ (figures 1, 2, 3, 4) are the following [1]-[11], [13]-[14]:

- It was discovered in the year 1895 on a side of a hill near Ghelari^{1, 2, 3}, the district of Hunedoara: the place where it was discovered is called *Valea Caselor* (the Valley of the Houses)^{3, 4}.
- Iron mines¹ were discovered and exploited in the area of Ghelari: in Antiquity (the Dacian^{5 - 11} and Dacian-Roman¹¹ periods), the early Middle Ages, the Middle Ages, later¹².
- It was (plausibly) used during the 9th century and later^{13, 14, 15-22}.
- It (plausibly) consisted of: high hearth, of a tronconic shape, the upper side diameter was $D = 2R \approx 0.65$ m, the basis diameter was $d = 2r \approx 0.33$ m, the height was $H \approx 1.8$ m; at the upper side the furnace had an opening through which ores and charcoal were introduced, a cover, an opening (under the cover) which made the connection with the funnel through which the bunt gases came out, the funnel was tilted, buried in the side of the hill, the funnel was (relatively) long ($1c \approx 1$ m), it

* In the Romanian language *cuptor*; is noted C.

- also had a loading platform, a side inlet through which air was blown and thus the fire was activated.
- Operational characteristics: the furnace cross section was (relatively) small, the output of molten material was (relatively) small, the height of the furnace was (relatively) big, the burnt gases exhaust funnel was (relatively) long, the (natural) draught was strong, the reached temperature was (relatively) high.
 - The use of the furnace (certainly) lasted a long time: a piece of cast iron was found inside the furnace^{23, 24}.

The time when the furnace was built (established by means of archeological and historico-morpho-functional arguments) is approximated.

The reconstitution and the sketch (idem) of the archaic furnace were done in 1906 by LATINÁK GYULA, who published the results of his research in the paper entitled: (1906) «A vajdahunyadi m.k. vasgyár és tartozékai», *Bányászati és Kohászati Lapok*, XXXIX 13, 3 and following; the reconstituted sketch is figure 1.

Considerations on this chronological sequencing and reconstitution are also presented in (1903) *Natura*, 6, 38, and in MOROIANU, D.; STEFAN, I.M. (1963) «*Focul Viu*»/«The Living Fire», Bucuresti, Editura Tehnică, PILLY, N. «From the Past of Cast Iron Production», *Metalurgica*, 18 (11) 642-643, CHINDLER, N.; POPAS, S. (1969), «*Contributii la istoria metalurgiei feroase în imprejurimile Hunedoarei*»/«Contributions to the History of Ferrous Metallurgy in the Areas around Hunedoara», *Metalurgica*, 21 (5) 313., MAGHIAR, N.; OLTEANU, ST. (1970) «*Din istoria mineritului în România*»/«From the History of Mining in Romania», Bucuresti, Editura Tehnică, 102.

The researchers who studied this «*casus*» showed that this reconstituted archaic furnace has certain operating, functional and typological features which determine the «type» which can be compared (i.e. it displays certain similarities, analogies, differences respectively) to certain known archaic furnaces discovered in various regions in Europe, dated (reasonably accurately) and characterized (idem)^{15, 16}. C_{H.I.}^{melt.ores} is compared with:

a. furnaces named Catalan (Corsican): such furnaces had a circular shape, were lined with stones, were widened towards the outside (they were shaped like a square well), the air (necessary for the intensified burning) was produced by some manually operated (non-hydraulic) bellows, the air draught was injected in the furnace from bottom to top; such technical systems were used (attested; relatively frequent) in the French-Spanish area of the Pirinei mountains (Ariège, Navarra and others) in the early Middle Ages (attested in the 10th and 11th centuries and later);

b. typical furnaces of the 16th century^{16, 17, 18, 19},

b.1. *Rennfeurofen*: there is an over-raised hearth²⁰, of a small size at the level of the ore and slag outlet, on this hearth there was kept the unprocessed iron obtained in the hot furnace, the unprocessed iron obtained in the hot furnace, the unprocessed iron kept on the high hearth was cooled, the slag was drained through the furnace outlet;

b.2. *Stückofen*: the hearth of this furnace has a square section, it is (exclusively) built of stone, the opening in the upper side is wider²¹, the body of the furnace is covered (with a clay wall/clay blocks) when the «charge» of molten iron ore was formed in the furnace, its users

would break it and take out the product (*Stück*)²², when the furnace was next used it had to be covered again and re-filled with ore, heated and broken and the products (*Stück*)²² taken out again.

c. It is noted that:

c.1. Certain historical-morpho-operational features – i.e. the «kind», of «the Catalan furnace», C.C., are common with those of the «Hunedoara ancient furnace» C_{H.I.}; the operating and the extraction principles.

c.2. It is noted that certain historical-morpho-operational features – i.e. the «kind» of the «Hunedoara ancient furnace». C.H. are different from those of the «Catalan furnace»; they are more primitive.

c.3. It is noted that the main historical-operational features – i.e. the «kind» of the «Hunedoara ancient furnace», C.H., are different from the «Renaissance furnaces»¹⁶, C.R.

d. It is (probably, orientatively) evaluated: «the Hunedoara archaic furnace», C_{H.I.}, was built and used before any of the oldest «Catalan furnaces», C.A.C. = C.C.: therefore, it dates (*idem*) back to the historical *Tempus* period T » centuries IX-X p.J.Ch.

The building of replicas, in natural size of this remarkable technical artefact and their proper social valorification^{25, 26, 27-40} is, in our opinion, highly necessary: it must be made as soon as possible by very active and hardworking experts.

Another archaic furnace was found in the 1981 also near Ghelari, judetul Hunedoara; it is dated by Lazăr Mucea who suppose that it was built in XVII century (figures 5, 6). The existence of these archaic paleo-mediaeval furnaces certifies that in the area of Hunedoara there was a significant social activity, emphasized by superior technical activities: such forms of social *modus vivendi* continued during the following centuries⁴¹.

Final notes

1. The iron ore mining and the extraction of iron by metallurgical processes (foundries) have been carried out in the area since ancient times; a) (probably) as early as the Pre-Dacian period; b) (plausibly) since the Dacian period: there are visible traces attesting it; c) (certainly) since the Roman period: there exist furnaces, slag dumps, and others.

2. Important non-ferrous ores (gold, silver, copper, zinc and others) were not found near the archeological site where this (paleo-mediaeval) artefact was identified; such ores (gold, silver) were identified and processed in ancient times, the Middle Ages and later¹², in the neighbouring areas, in the mines in the Apuseni mountains: the «Ardelean quadrilater» including Băita, Barza, Brad, Abrud (*Auraria Major*), Zlatna (*Auraria Minor*) are at about 50 km away from this *situs*.

3. The origin of the toponim (plausibly) is: the name of the hill (in the Romanian language *deal* – the inhabitants of Ghelar are those from the «*Gheal*» (people living in the hill: *deleni*/hill-people).

4. The name of this place (explicitly) indicates that there were inhabited houses in the neighbourhood, in relatively old historical periods (probably during the Middle Ages and later as well).

5. At Sarmisegetuza Regia (Kogaionon) which (plausibly) was the capital of the Dacian Kingdom (during the reign of king Burebista⁶ (he died in the year 44 b.J.Ch.), during the reign of king Decebal⁷ (who died in the year 105 a.J.Ch.) several big iron lumps, «*lupe*», were discovered by metalographical analysis; they come from the Ghelari mines [the identification is verisimilar: a) traces of some old iron mines were found in the Ghelari area, b) there had/has not been another area with iron ore in the neighborhood, c) the comparison (of the substances of these ancient lumps with those of some typical ores from Ghelari) was possibly metalographical analysis, d) the ore was transported (from the mining sites to the surface and from the entrances of the mines to the processing areas i.e. furnaces, workshops) (covering distances of about 50 km on rough roads) using the transport means of the period: (plausibly) there were used thick cloth sacks, baskets, throughs, chutes, pulleys, «wooden boxes» – i.e. carriages with thick wooden wheels (rollers) which were moved on wooden tracks (quasi-rectilinear), sleighs, carts; the used moving force (pull-push) was human (workers, soldiers, slaves, convicted), animals (horses, oxen, dogs); was also used the hydraulic power of certain waterfalls (to wash, move mill wheels, crash ore, move charges and others).

6. The «classic» period – i.e. 1st century b.J.Ch. was, during which the state fully extended and the Daco-Getic culture and civilization reached its peak.

7. The final period – i.e. 1st century a.J.Ch. – before Dacia was conquered by the armies of the Roman Empire⁸ led by Emperor Traian (around 52-77)¹⁰.

8. The second Dacian war⁹ ended with the conquest of the capital¹⁰, the capture¹¹ and death of the king and the beginning of colonization of this new province of the Roman Empire.

9. The conquest of Dacia (the surrender of the chiefs of certain fortresses, the moving of the inhabitants of fortified places and other aspects in Dacia) are represented on the bas-reliefs of Traian's column in Rome.

10. Detailed written descriptions of the two wars between the armies of the Roman Empire and those of the Dacian kingdom are not known; the diary of Emperor Traian (entitled *De Bello Dacico*) is mentioned in certain works written during the Antiquity, but the original text was lost: no recent copies have been preserved. A single phrase has been preserved (given as an example by the grammarian-rhetor teacher Priscian in the 3rd century a.J.Ch.) which includes only a piece of geographic information (*Inde Berzobis deinde Aexim procesimus*).

11. The first stage was *Dacia capta*, when the armies of the Roman state led by Emperor Traian, the first provincial to become the highest leader of the largest *regnum Anticum* and declared by the Senate and the people *optimus princeps* destroyed the strongest «barbarian» state of the period.

12. Up to the present.

13. Certain authors believe that this furnace-relic (or similar ones, not preserved) were built as early as the 1st century a.J.Ch..

14. According to the dating of the stratigraphic characteristics of the site where the artefact was found: in the «archeological context» no clues for dating have been found¹: therefore, the dating, based on specific arguments (archeological¹¹, historical, morpho-functional) is rather arbitrary.

15. The existence of these typical archaic furnaces is well documented (various mentions in medieval documents, rigorous researches which describe and analyze them: Bi-

ringucio, *Pyrotechnica*, 1540, and others).

16. The painting of Ioachim Patenier (1485-1545)¹⁷, the classical Saxon scholar Georgius Agricola Georg Baur (1494-1551) in his monumental treatise-work *De re metalica libri XII*, book IX, fol.330, published in 1556 in the Latin language and in 1557 in the German language, princeps edition: Vanuccio Biringucio, *Pyrotechnica*, 1540¹⁷.

17. A documented study of the evolution of the iron ore reduction furnace was carried out by the researcher V. Wolman; it is entitled *Instalatii si procedee pentru obtinerea directă a fierului si a efectului prin reducerea minereului* – «Equipment and Techniques for the Direct Production of Iron and for the Effect of Ore Reduction». This paper was not published. A few researchers could read the manuscript and were given information from the author himself).

18. Renaissance: C R.

19. They were built and used in certain areas in the Alps and Carpathian mountains.

20. The technical term in German is *Vorherd*.

21. The furnace resembles the Scandinavian peasant furnace called Osmund. The *Stückofen* type furnace consists of two Osmund type furnaces.

22. Such furnaces therefore had to be broken when each *Stück* was taken out: they were single use machines producing iron charges.

23. The existence of this part found on the hearth bottom also indicates that this artefact was used until «the last moment» (when it was abandoned; later it was covered with a layer of earth, which allowed for its long-term preservation); the micro-physical structure and the chemical composition of this parts is very similar to that of some pieces of cast iron produced from melting other iron ores in the region.

24. These morphological features are those of the artefact rebuilt of the original materials.

25. Some replicas are displayed in various museums: that of metallurgy in the Hunedoara works, The Technical Museum Dumitru Leonida in Bucharest, the Museum Civilizatia Traditională Populară (Folk Tradition Civilization) ASTRA in the Dumbrava Sibiului.

26. The display of this artefact in several *museum vivum* should be accompanied by adequate informative appendices: (multilingual) inscriptions with explanations (essential; clearly presented), leaflets, photographs, mini-replicas; this information should be included in books, guides, almanacs and others.

27. The reconstitution (from original materials) was made after the primitive furnace was discovered *in situ* in order to achieve an expressive piece, that could be exhibited (in museums, exhibitions)^{28, 29, 30}.

28. I do not know the names of the persons who made the discovery (in 1895) neither of those who reconstructed it (*idem*).

29. The original (with certain reconstitutions from original materials)^{30, 31} was purchased by the custodians at the Science Museum in London³².

30. I am not familiar with the detailed circumstances under which the original (*idem*) was brought from its original place to the Science Museum: being interesting, the artefact was exhibited (I do not know exactly under what circumstances) at an international exhibition in Buda-Pest in 1897 (capital city where several exhibitions were organized as part of the *Millenium* festivities celebrating the settlement of Hungarian nomad tribes in Panonia), at this exhibition it was remarked by experts (engineers, historians, purchasers, business people, cultivated people, and others) who made an advantageous offer to the persons who owned

this relic (found on the territory where there were iron mines whose products were used by the Metallurgical Works in Hunedoara³¹); the owners agreed to sell it to the experts, who took the part to Great Britain (I am not aware of the history of the part, neither of the way and date when the existing exhibit was displayed in the Science Museum).

31. Hunedoara works began to be built in 1882; the first furnace was set into operation in 1884.

32. In the Science Museum there is displayed a miniature copy³³ (the scale is of approximately 1/4) of the original furnace rebuilt (*idem*) (figure 2) with a short inscription. (I am not familiar with the documentary sources used to make the model in England.)

33. I do not know whether the rebuilt original (*idem*) still exists (and is kept in a storehouse) or was destroyed; in my opinion this rebuilt –original still exists in a storehouse of the Science Museum³⁴.

34. The custodians from The Science Museum appreciated the value of this old exhibit and specifically included it in the structure³⁵ of this Technical Pantheon:

a. the evolution of metallurgy (iron and others) is (quasi) chronologically³⁵ presented: there are (specifically) presented important exhibits, patterns, «museum recallings» from different (quasi-consecutive) stages and significant areas;

b. «the Hunedoara furnace» C_{H.I.}, was exhibited (in 1992) as a size 1/4 model, in the Iron and Steel Gallery Department^{35, 36} in the first room*;

c. this complex display is the second complex artefact displayed in chronological order: the first exhibit is a rudimentary furnace with primitive bellows which was used (many centuries ago³⁷) in the Sudan³⁸.

d. The model of the furnaces is the first one in a show case³⁹; the generic inscription mentions the significance of the exhibit (primitive iron furnace), the detailed inscription specifies the place where the exhibit was found and its age⁴⁰: model of primitive iron melting furnace found near Gyalár Hungary (*sic*) probably dating back to the 9th century (*sic*). The furnace had been cut of solid rock and was semicircular in form, the front being up with dressed stoned. In the models technical file of Science Museum are given the inventory coordinates (the date when the model was made: 1925; the serial number 115) and some short technical information (figure 3, 4).

1. Certain exhibits are relatively accurately dated (period, century, a.s.o.), others are very accurately dated (in the place where the exhibit was found accurate «chronological clues» were also found: coins, historical references and others).

2. An inscription specifies: this gallery has been developed with the aid of the British Steel Corporation together with other organizations in the British Iron and Steel Industry.

3. In the «primitive era».

4. A similar system is still used in the 20th century in certain areas in the Sudan.

5. The second case window.

6. Assumed by custodians: according to the estimations made by the researchers who studied the relic *ab initio* (Latinák Gyula, and others).

7. In the neighborhood of Hunedoara, in the Western Carpathians area robust trucks were used from very remote times (vaggons: carriages; made mainly of wood, the rails, the switch of systems); the structure of the boxes, the use of some very ancient «mining trucks» is certified beyond doubt by the preservation of these venerable technical artefacts kept nowadays in Verkehrs und Baumuseum in Berlin and Deutsche Bergbau Museum in Bochum, Germany.

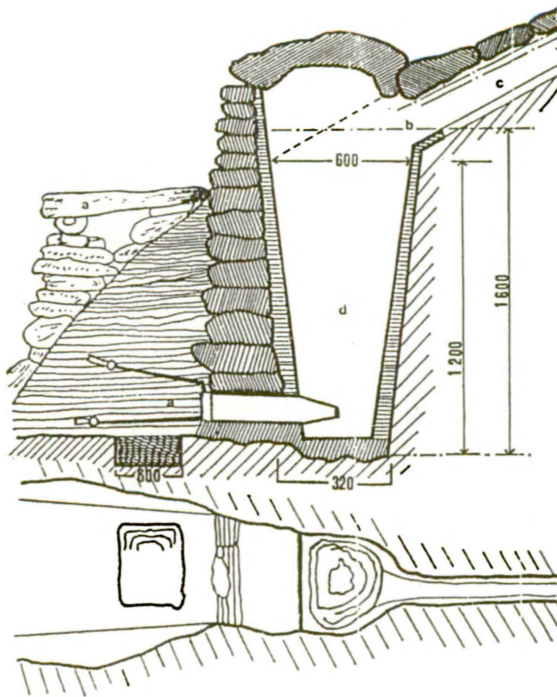


Figure 1. Sketch of archaic furnace, $C_{H.I.}$: transverse section.



Figure 2. Image of the $C_{H.I.}$ archaic furnace replica kept at the Science Museum in London.

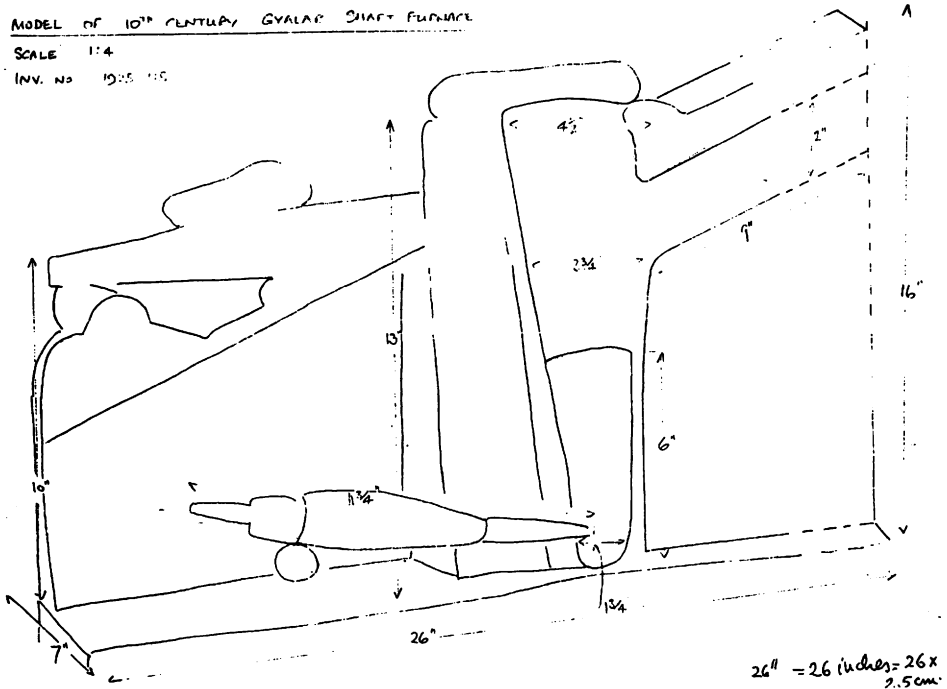


Figure 3. Sketch of C_{H.I.} archaic furnace in the Science Museum records.

ANCIENT IRON BLAST FURNACE.

(Scale 1 : 4.)

Made in the MUSEUM.

This is a sectional model of an old furnace found near Gyalar, in Hungary, and exhibited at Budapest in 1897. It is believed to date back at least a thousand years.

The furnace had been cut out of the solid rock and was semicircular in girth, the front being built up with dressed stones.

The furnace was 2 ft. in diameter at the chimney and 1 ft. outside at the bottom of the hearth. The total depth was 5 ft. 3 in. The lower portion of the furnace was lined with refractory material. The blast was introduced through a pipe passing through the lower part of the front wall. The bloom of iron was probably removed through an aperture made at the bottom of this wall, though the original description of the furnace does not make clear precisely how this was carried out. The furnace was provided with a cover, and a charging platform. A mass of iron was found in it.

Inv. 1925—115.

Figure 4. Inscription referring to C_{H.I.} archaic furnace.

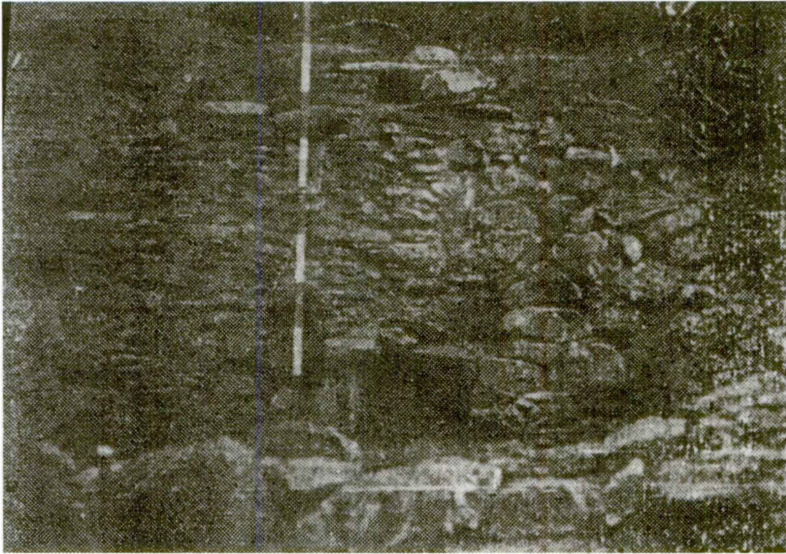


Figure 5. Photograph of $C_{H.II} = C_{H.R.}$ archaic furnace.

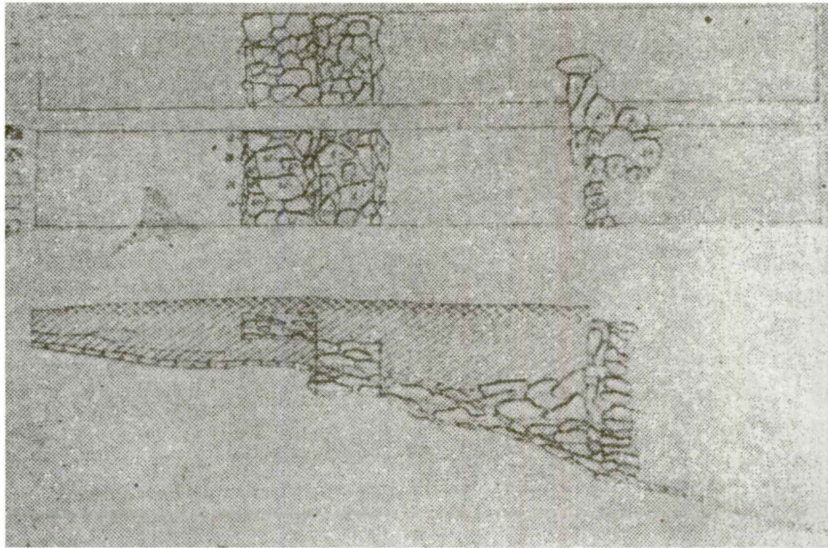


Figure 6. Sketch of $C_{H.II} = C_{H.R.}$ archaic furnace.

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