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THE EXPLOITATION AND PROCESSING OF IRON IN ROMAN DACIA

COMPENDIUM

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Chapter I – Introduction

The work summarized in these pages tries to present, with the limitations of the present-day knowledge of Romanian historians and archeologists, the level attained by the Daco-Romans in the extremely important field of iron ore extraction, enrichment and processing, the techniques used for this purpose, and those used in workshops for giving the necessary characteristics to the resulting products, tools, household objects etc.

The corroboration of archeological information with the few literary ones and the frequent comparisons with similar situations from Antiquity, especially those from other provinces of the Roman Empire, have led to formulating hypotheses and conclusions even in such fields where serious question marks have arisen.

The progress made in the last few decades by archeologists, geologists, metallurgists, physicists, chemists etc., within multidisciplinary research, has also proved to be viable in the field the present work deals. Analysis bulletins, some used in the present work, have supplied additional, eloquent data concerning the origin of some ores and rocks, the techniques used for improving their content, have provided answers on the temperatures obtained in various thermic installations and, closely connected with these, the quantity and quality of the fuel used. A series of tests performed by specialists in factory laboratories have allowed not only the establishment of quality parameters of the tools of Daco-Roman blacksmiths, but also the techniques they used, and have made comparisons with similar objects, made by blacksmiths from other provinces of the Empire, as well as with modern ones, possible.

The author wishes to sincerely thank everyone that has helped him in every way.

Chapter II – History of the research

Archeological diggings from the past century have substantially contributed to enriching the information on Daco-Roman civilization from the 2nd and 3rd century A.D.
This has materialized in the synthetic presentation of the above mentioned period in treatises of Romanian history, published in the postwar period. Added to these are the regional syntheses owed to C. Daicoviciu and D. Tudor.

Different aspects of provincial economic life have been analyzed in monographs by V. Christescu, G. Popilian, V. Wollmann and N. Gudea.

The punctual issues of mining in ancient Romanian territory have also come to the attention of researchers. At the same time, the functioning of metallurgical ovens and iron ore reduction techniques have been studied based on archeological findings and metallographic studies. Metallurgical workshops, with their inventory of tools, have also drawn the attention of historians.

A large quantity of iron objects found in systematic archeological diggings or fortuitous discoveries have been published in numerous digging reports, articles and studies. Therefore, iron objects from *villa rustica*- type settlements, such as Aiud, Apoldu de Sus, Cincis, Ciumafaia, Hobita or Valea Chintaului have been introduced in the scientific circuit through studies, more or less comprehensive. Other numerous iron objects have been published in works on *castrum* and the afferent military *vicus* , such as those from Bivolari, Bologa, Brancovenesti, Bretcu, Buciumi, Bumbesti, Catunele, Copaceni, Gilau, Hinova, Hoghiz, Ilisua, Cincsor, Jidava, Jupa, Mehadia, Moigrad, Olteni, Orheiul Bistritei, Tihau, Racari, Rasnov, Romita, Romanasi, Sapata de Jos, Sloveni etc.

Iron pieces, fewer indeed, have been discovered in rural settlements of the province, such as those from Aiton, Boita,

Casolt, Gornea, Micasasa, Moldova Veche, Obreja, Tichindeal and others in south-western Dacia. On the other hand, iron artifacts discovered in urban settlements are more numerous: Sucidava, Drobeta, Romula, Potaissa, Porolissum, Tibiscum, Ulpia Traiana Sarmizegetusa etc.

Archeological diggings in the province's necropolises have brought to light a series of small iron pieces tied to the funeral rituals observed in the Roman era.

Certain categories of tools (agricultural, blacksmithing, carpentering etc.) have enjoyed constant attention. These have been published in explicit studies focused mainly on pieces discovered either in intensely researched archeological sites, such as Tibiscum, or in deposits, such as those from Caianu Mic, Dedrad, Lechinta de Mures and Marculeni.

As far as iron locking mechanisms are concerned, they, as well as other *instrumentum* – type pieces are generally published in different writings, without a special focus drawn upon them. In Romanian archeological literature there is but one study that proposes a typology of keys from Roman time Dacia.

The study of Roman Dacia iron metallurgy and iron products has been greatly facilitated by the possibility of comparing Daco-Roman pieces with objects discovered in other provinces of the Empire. From this standpoint, the publishing of special writings on technological problems and the study of certain categories of pieces discovered in the Roman world or even in pre-Roman Dacia have been very helpful in identifying local elements and foreign influences from the province of Dacia.

Chapter III – The exploitation of iron ore

As a result of the Roman conquest, Dacia entered the orbit of the classical slave system and enjoyed an unprecedented development of the material culture, the progress being generated by a continuously extending, diverse and flourishing economic life. One of the major branches of Roman Dacian economy was mining. The development of the mining of subsoil riches, through the extraction of various metals, including iron, served mainly to satisfy the domestic needs of the province.

It is the overwhelming role played by the extraction and reduction of iron ore in the progress of Daco-Roman society, completed with the processing and transforming the metal into a wide range of tools and various other objects needed by the Roman civilization that has led us into studying the different aspects which this decisive branch of economic life implies, including mining sites.

The large quantity and diversity of iron objects, tools, weapons and pieces of daily use, discovered in every settlement in Roman Dacia, both civil and military, implies the large scale mining of the iron ores. However, our archeological literature, the older as well as the more recent one, is relatively scarce in indicating the extraction sites of the iron ores. This is due to, on the one hand, the absence of ancient literary sources on mining iron ore in Dacia, and on the other hand, the fact that medieval and modern exploitations have erased the traces of ancient Roman ones. In this context, the effort to identify Roman exploitations, a major problem that constitutes the very basis of iron metallurgy, has to rely on analogies with similar situations from the other provinces of the Empire, as well as on field observations, the study of geologic literature and the outcome of archeological research from past decades, even if these,

including the surface ones, were not necessarily aimed at spotting Roman mining sites.

A different treatment of iron ore deposits is therefore necessary, the more so as literary sources on the extracting activities, as we have shown, are missing, and the mines have been continuously exploited all through the Middle Ages and the modern era, resulting in the disappearance of ancient traces, or the confusion with newer ones, with the few exceptions that we will present you as follows. Even more, the medieval mining techniques evolved too little since Roman times, which can be misleading when it comes to identifying Roman vestiges.

The certain exploitation sites, visible from the 19th century through today, were those from Tara Hategului, from Valea Cernei and the Cerna basin, in the area now known as Hunedoara, well renowned for its exploitation of iron ore since Antiquity. Mining sites are found in several locations on the western side of the Poiana Rusca Mountains, which implies the presence of many small miners' settlements. The administrative center of the sites was at Teliucu Inferior (Hunedoara county).

The nearest mining site to Teliuc was at Cincis (Teliuc commune). Traces of a rural miners' settlement were discovered here, with ceramics, grinding mills and a *villa rustica*, and close to it, a necropolis with a funeral building and 17 tombs that probably belonged to a leaseholder or an owner of the iron mines, that used local workers for mining the ore and who were buried alongside their master as the funeral inventory of the tombs shows. This inventory consists of Roman and Dacian products and pieces of iron ore which were purposely placed there as a connection with their occupation.

Another area with certain mining sites of iron ore deposits, as well as other ores (copper and lead) and precious metals (silver and gold) is that of the mountainous regions of central and eastern Banat. Here there were small mining sites in the Semenic Mountains, on the upper Timis valley and its

tributaries, but they were modest in comparison with those from the Poiana Rusca Mountains and especially those from the Apuseni Mountains, where it is well known that precious metals were mined on a large scale.

Alongside the certain mining sites mentioned above, there are clues on the exploitation, in some cases certain, in others only probable, of some deposits or others.

So, in the certain sites' category fall the ones from Fizes, Sosdea, Berzovia and the Sureanu Mountains near Dacian Sarmizegetusa.

Another category of iron ore extraction sites is represented by the possible ones, considered as such based either on the presence of iron ore and the sporadic discoveries of scoria and charcoal, or on the existence or lesser studied Roman settlements and even of an agglomeration of settlements. Therefore, iron and magnetite deposits are known at Ulpia Traiana Sarmizegetusa as well as in the vicinity of the town, in the Hategului depression.

In eastern Transylvania a fairly large number of such settlements are known, both civil (Cristesti, Mugeni, Tg. Secuiesc) and military (the *castrum* of Orheiul Bistritei, Brancovenesti, Calugareni, Sancraieni, Imlaceni, Odorhei, Sanpaul, Olteni, Comalau and Bretcu), the economic life of which cannot be reduced to practicing agriculture and breeding livestock for supplying the population and the soldiers.

This is probably the case with settlements from eastern Dacia, whose economic life may have also been in connection with mining iron ore deposits found mainly in the Calimani, Gurghiu and Harghita Mountains.

Mining activity during Roman times implied learning some notions that would allow the recognizing the deposit, not to mention the complexity of the knowledge needed in the process of the ore reduction. The study of literary sources has proved that the ancient miners knew the process of prospecting

and processing underground resources. For example, Pliniu documented the existence of exact notions on the location of the ore lodes and the sterile layers in deposits. The choice of mining techniques and procedures, depending on the layers of rock, the inclination and thickness of the deposits, as well as the content of the ore (the degree of recovery through processing) constitute themselves the evidence for the existence of precise notions on the extraction process: the prospecting, the research and the recognition.

The iron ore extraction procedures and techniques in Dacia are similar to those known in other parts of the Empire and described by ancient authors. They can be revealed based on traces and field observations, on the few mining tools discovered and on the analogies with the extraction techniques of precious metals, that were better known in the Empire and in Roman Dacia.

Mining technique also involves solving other problems confronting the Daco-Roman miners: the access to the underground, communication with the surface, the proper extraction of the ore, supporting the galleries, underground lighting, ventilation and water evacuation.

The means of exploiting a deposit depends mainly on its condition: if the mineralization is on the surface, surface mining is enough, but underground mining is necessary if the deposit lies deeper. As a rule, the nature of the deposit (e.g. compact layer, sub vertical lode, stratified deposit) requests different mining methods, regardless of the nature of the metal being extracted.

Naturally, mining on the surface is much easier than underground. In many cases, such an activity could be performed in as simple a way that it could hardly represent a mining method altogether.

The oldest mining works were performed on outcrops that could be exploited on the surface. Gathering ore from the

surface does not require a special technique. Usually, shovels were all that was needed to gather and lift the ore pieces. The only problem arising was that of organizing the yard, that is distributing the work tasks concerning the exploitation and transport of the ore to the washing installations.

In an intermediary position, between the outcrops and the underground deposits, lie the quarry works, especially those at the ends of the lodes or the so-called 'iron caps'. As long as surface exploitation is not too deep, the true mining works can be avoided. With very rich ores, mining was not so difficult, as the ore is generally crumbly. At the same time, it is often disseminated in the layers of sterile rock. As a result, hewing became difficult. However, regardless of the method, it was usually simple: the workers extracted the ore at their feet and in front of them; gradually, the quarry deepened until the solidity of the 'faces' of the ore became insufficient and, therefore, proper mining works were required.

As the surface ore reserves became scarce, underground excavations were performed. Underground mining is mentioned by ancient writers, and traces of Roman time mines can be seen in many provinces of the Empire, including Dacia. The information ancient writers rendered, though interesting, does little to shed light on how the ore was mined. It is the study of traces left by the exploitation that allow us to know the methods and procedures used in Roman times.

The first mining works resulted in extracting small quantities of ore. The pieces with a high content of iron were selected. For a long time, the works focused on highly mineralized areas or only ore free from sterile was extracted. However, ore enrichment, regardless of its nature, was used since immemorial times. During Roman times, this principle is sure to have been known and practiced.

The enrichment consists of the separation of the ore from sterile, and nowadays from the other ores it is mixed with.

The separation results in raising the content of brute raw material till close to a rich, if not pure, product. A perfect enriching work gives a sterile entirely sterile and the ore correspondent of its theoretical composition.

Then, like now, enrichment implied crushing, sorting, sifting and washing the ore.

If the method of exploitation of a deposit depends on its structure and not on the product being extracted, the metallurgic treatment varies not as much according to the nature of the ore, but to its chemical composition. Also, the procedures used and put in practice were less differentiated than they are today. At the same time, if ancient metallurgy used only the 'dry' method, nowadays, the 'wet' method is equally used.

Reduction furnaces (*furnaces*) constitute the essential element of iron metallurgy. For processing the mined ore reduction facilities were therefore built. They were erected close to the extraction site, the processing being conditioned largely by the existence of water sources, nearby fuel supplies and natural air currents necessary for the acceleration of the reduction process. The absence of forests needed both for the burning process, and for reinforcing the mines or heating the rocks for them to tear off, has even led to abandoning certain mines in Roman times. The building place of reduction facilities depended on a lower scale on the existence of fireproof materials, used for coating the furnaces.

The iron ore reduction process was well known during the Roman period, including Dacia.

When Roman smelters reduced pure or almost pure oxidized or carburized ore, no fluxes were necessary as carbon action was sufficient to obtain the metal and there was no need for slagging. The reduction of scanty ore required fluxes.

The problem was solved by using old slag (crushed and mixed with the ore), sand or limestone.

The high temperatures (over 1000° C) needed to start the reduction process were obtained by burning wood and charcoal. Mineral coal, though known in Roman times, were less used, because of the low caloric output and their sulphuric content that hindered the reduction process. Peat was used during Roman times only in Britannia.

In Antiquity, including the Roman period, iron was produced by the method of direct reduction, in furnaces as described above. After preliminary operations the ore was subjected to, in order to facilitate the reduction, were over, the furnace was filled with successive layers of ore and charcoal, and sometimes the fluxes we mentioned.

Metallographic tests carried out on samples of iron slag showed that the furnaces reached high temperatures (around 1000- 1100°) able to start and maintain the reduction process. Based on the same tests, we can now comprehend the three main stages the ore passed through in this process: in the first phase the agglomeration of the ore is produced; next, the gradual reduction starts, when small granules appear in the ore; then, the reduction is accelerated, and earthly components start to melt and slag and in the final phase, metallic iron drops and granules fuse to form the outline of the lump. This is also the phase when the melting of earthly components ends and they stream down, together with a part of the metal, to the bottom of the furnace to form the slag.

Chapter IV – The tools

French historian F. Bénoit once said: 'The history of the tool is the history of civilization itself'. Tools are not made or perfected until there is a need for it. They were not invented by one person, but are rather the result of human intelligence and, consequently, are a material and social reflection of a civilization.

The fact that tools are everyday objects and not items of prestige is an important element. Therefore, every manufacturer modifies them according to the raw material at his disposal, but also to his intentions or ability. They are personal goods: being manually made, their shape depends on the maker's knowledge. They can supply us with information on regional customs or on the assimilation of foreign material culture elements and craft techniques.

As a consequence, tools are dedicated to processing raw materials and rely on the muscular energy of their user. However, we have included in this text a certain amount of instruments which are part of the equipment of various craftsmen, such as anvils, compasses etc.

The information we have on tools from Antiquity is given by three sources: written sources, figurative representations and archeological findings. Written sources are generally less useful. Ancient authors didn't find it necessary to describe the exact shape and destination of tools, everyday objects being considered unworthy of any interest. On the other hand, the rare, more elaborate texts are hindered by translation difficulties.

Figurative representations are more instructive altogether. More frequent on tombstones than on bas-reliefs and mural paintings, these representations show the shape of the tools, the way they were used and the craftsman they belonged to.

As for the archeological findings, beside information on the shape of the tools, they allow us to gain further information on the chronological and cultural context or on the manufacturing techniques.

Archeologists have shown little interest in the study of ancient tools. A few studies were published at the beginning of the 20th century, mostly works on the history of technological creation. From this standpoint, there is a certain development in

the last four decades of the century. Unfortunately, the present status of the investigations leaves the researcher with few synthetic studies. Therefore, gathering information on the technologies of manufacture and the shape of tools from different studies and reviews is necessary.

The existent studies on tools refer mainly to the provinces of Germania and Britannia. As the tools may differ from region to region, this situation has the disadvantage of providing fewer analogies with tools discovered in other regions, namely Dacia. This reality needs to caution us about jumping to conclusions based on such analogies. The Romanian researcher is often confronted with a terminology issue. Some German or English words lack the proper translation due to morphological specificity. For other words there are no correspondents in the Romanian language. The small thickenings that margin the handle orifice of some tools, such as axes or adzes, lie within this category. Consequently, we named them ‘wings’.

Tools constitute a very vast object for research. The absence from Romanian archeological literature of a monograph on iron tools from Roman Dacia has determined us to present the pieces discovered in archeological diggings and published in various studies in a typological framework based on similar tools known to other provinces of the Roman Empire, in an exhaustive catalog. So, one purpose of the study of tools from Dacia is the elaboration of a reference *corpus*. We hope the present text will make its contribution in this respect.

We focused less on dating the tools. Their basic shape has not changed much since Roman times. As a result, just a few details pertaining to the shape of tools can contribute to establishing a chronology.

A human dimension can be added to the slow evolution of the shapes. Craftsmen were so keen on making these tools, that they were kept, maintained and used for centuries. This

respect owed to the tool probably explains the presence of pieces of Dacian origin and tradition in settlements from the 2nd and 3rd century A.D. The craftsman's affection for his tools can be seen in the stamps and ornaments applied on them and in miniature replicas of the tools.

The craftsman invents his own stamps and ornaments, which, in turn, help him recognize his equipment. However, archeologists rarely find these distinctive marks, for they were applied on the wooden rather than on the iron parts, as shown in both medieval and modern tools.

Nowadays, as probably in Roman times, too, regional differences can be seen in both the shape and name of the tools. Through written sources we found many Latin words, but in few cases were we able to understand the destination and usage of the respective tools.

However, we tried to make connections between Latin terminology and the present one. Thus, we were able to identify 14 distinct tools, though some were named by the Romans with the same word, and others had different names: the anvil (*incus*), the scoop (*ligula*), the hammer (*malleus* or *marcullus*), the tongs (*forceps*), the chisel and fishing tap (*caelum*), the file (*lima* and *scobina*), the compass (*circinus*), the axe (*securis*), the adze (*ascia*), the drill(*terebra*), the drawing knife (*scalper* or *scalprum*), the saw (*serra* and *serulla*) and the plane (*runcina*).

The tools were taken into account depending on their destination and the nature of the work being performed with them, under the following three fundamental aspects: structure, hardening and angle of attack. By structure we understand the shape, dimensions and handling of the piece; by hardening, the higher or lower ductility of the ferrous material. The angle of attack refers to the position of the active part of the tool opposite the surface where the lucrative action or movement takes place: when the active part is perpendicular to the surface

of the piece, it forms a null angle; when the active part lies in front of this perpendicular axis on the direction the action takes place, the angle is negative; in the reversed situation, the active part is inclined to the back, and the angle is positive. This standpoint is important for knowing whether a tool served only for cutting or scraping, or both. Unfortunately, most tools being in an advanced state of corrosion, it is difficult to draw a conclusion in each case.

For a classification of tools, we took into account the three types of their usage, established by A. Leroi - Gourhan and reviewed by P. Varéne in conjunction with the processing of the rock: imposed percussion, striker percussion and launched percussion. By imposed percussion one means the pressure of the muscular strength exerted directly upon the place of action, imposing it a constant, linear or gyratory movement. In the case of striker percussion, the action resulted from the strike force of the striker upon the place of action of the tool imposes it a predetermined, linear or oblique movement. By launched percussion one understands the direct action of the striker or of the cutting tool, held or moved, as is the case of the hammer.

Imposed percussion tools are, among others, the tongs, the drill, the saw, the file or the drawing knife; striker percussion tools are the chisel and the fishing tap; launched percussion tools are the hammer, the axe and the adze.

Percussion tools, with or without striker, are classified, in turns, in four categories, depending on the successive moments of the work: drawing tools (the chisel and compass); drilling tools (the drill); cutting, thinning, shaping and molding tools (the fishing tap, the axe, the adze, the saw, the scoop); finishing tools (the file, the plane).

Blacksmithing in the ancient, and consequently, the Roman world, was meant not only to create objects of daily usage, weapons and tools, but also to create and constantly

improve specialized tools, suitable for the many operations blacksmithing implied. As a result, blacksmithing constituted in Roman Dacia, as elsewhere, an essential element of the technological progress which was the basis for the progress of all other fields, where the use of iron products determined work productivity, and implicitly, the level of production.

Various archeological findings suggest that in Roman Dacia wood was largely used, both as building material for various urban and rural buildings, *castrum* and other fortifications, and as raw material for manufacturing pieces from a household's inventory, from everyday objects to intricate furniture. Wood was processed, for its numerous uses, with the help of carpenter tools, adapted to specified operations.

Wood-processing tools were already in great number in Roman times. These are, for example, the axes, the adzes, the saws, the planes, as well as all kinds of wedges, hammers, nail tongs, taps, drawing knives, drills and files, not to mention instruments like the compass or auxiliary tools, like the joiner's bench.

All the craftsmen that dealt in wood processing had equipment which generally resembles that of the carpenter. Added to these were some special tools. Therefore, the latter are in some cases the only indication of practicing a craft or another.

In Roman times, agricultural activity was stimulated by the introduction of new methods of working the land and new species of plants. The improvement of grain crops, of leguminous plants, of fruit trees and textile plants necessarily determined an adequate transformation of agricultural tools and the emergence of new ones. The practice of different cultures needed the invention of polyvalent tools.

All these transformations were quickly recorded by ancient writers preoccupied with agriculture, as were by the representations of works and tools on mosaics, mural paintings

and sculptures. Numerous findings, gathered in deposits or *villae rusticae*, complete the picture of Roman rural life. It is not always possible to rigorously identify tools which served well determined works, either because iconographic representations are sometimes scarce, or because Latin authors gave different names to the same tools. These difficulties are further hindered by translation differences and interpretations among modern authors, as well as by the imprecision of catalogs in all countries.

Agricultural tools in Roman Dacia are relatively small in numbers, but tied to essential operations such as: preparing the land for cultivation, weeding and harvesting, cutting and grafting fruit trees and vines.

Chapter V- Locking mechanisms

The category of petty archeological material reflects, both quantitatively and qualitatively, Roman Dacia's material culture. Thus, even if it may appear trivial at first glance, this category of material has its significance, through the very essence of petty objects and through its inclusion in the wider specter of material life in Roman Dacia.

Keys constitute, as it is known, a category of household items. Though large in number and variety, and widely spread, the key study was neglected by Romanian archeological literature up to date. In Dacia, many keys, both as isolated items or as groups of items, were published in different writings, but without a special focus. An exception is the key index from the collection of the Museum of History and Art from Zalau.

Chapter VI – Conclusion

This chapter contains the final considerations on the whole of the subjects treated in the previous chapters, with a special focus on what is common in Imperial Roman civilization and what is specific of the province of Dacia.

At the end of this chapter one can find a list of abbreviations and the Romanian and foreign bibliography that was used.

The 67 drawings at the end of the work are generally arranged in the order requested by the mentioned chapters.

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