

GOLD MINING IN DACIA AFTER THE ROMAN CONQUEST

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Abstract: *The work presents the history of gold mining in Dacia, after the Roman conquest in 106 AD until the Aurelian retreat from 271 – 275 AD. Roman spoils of war from 106 AD are valued by researchers at 165.5 tons of gold and 331 tons of silver. During the 165 years of occupation, the Romans extracted 450 tons of gold and 900 tons of silver. For this, they brought from Hispania and Britannia the most modern gold mining and preparation technologies, which remained unchanged for almost 1500 years.*

Keywords: *gold, alluvial gold, vein gold, the gold of the Dacians, gold mining methods.*

1. Conquest of Dacia by the Romans

Of all the Dacian kings, the most famous and bravest was Decebalus (87–106 AD). He restored the unity of the Dacian state on a smaller territory than Burebista's state, but more centralized and powerful. His great misfortune was that precisely in this period the Romans, led by Trajan, started the wars, for strategic and political reasons, but certainly also with the thought of the prospect of capturing the considerable Dacian treasure. In the battles that followed, Decebalus managed to resist for several years, but he could not maintain the independence of the Dacians when the Romans, numerically superior and better armed, crossed the Danube at Turnu Severin, on the bridge built by Apollodorus from Damascus. It is very clear that the main purpose of the wars against the Dacians was the appropriation of their fabulous wealth of gold and silver. That is why the Romans did not conquer the whole of Dacia, but only a part of Transylvania, with the gold-silver deposits in the Apuseni Mountains, and a corridor through Oltenia that would ensure their access to this area.



*Fig.1. Ettore Ferrari – Decebalus and Trajan [1, page 39]
Bronze busts in the collection of the National History Museum in Cluj–Napoca*

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All contemporary historians agree that the one who made the most credible assessment of the spoils of war taken by the Romans in 106 AD. was the French historian Jérôme Carcopino (1881–1970), in a study published in the first issue of *Dacia magazine*, founded in 1924 by the Romanian archaeologist and historian Vasile Pârvan [2]. The financial disaster left by the emperors Titus (79–81) and Domitian (81–96) was saved by Trajan (98–117) in the second part of his reign. Researching and corroborating all the writings of ancient and modern authors, Carcopino comes to the conclusion that the Romans looted 165.5 tons of gold and 331 tons of silver from Dacia, with which they drained the marshes around Rome, expanded the ports on the Tyrrhenian seas and the Adriatic, they rebuilt the Nile – Red Sea Canal, built the *Aqua Traiana* aqueduct, the Forum, the Basilica and the Column, established two more legions and prepared the war against the Parthians. All heads of families in Rome, which at that time had about 1.5 million inhabitants, received a gift of 650 denarii (a silver coin weighing 4 grams) and were exempted from paying taxes for a year. Not to mention the 123-day celebrations, in which 10 thousand gladiators and 11 thousand wild beasts were engaged. The haughty empire was saved from bankruptcy, at the price of the desolation and enslavement of the richest territory of Dacia. Many Dacian men were killed in battle, about 50 thousand were taken as slaves, and others were enlisted in the auxiliary troops of the Roman army and sent to fight far from home, for the defence of the empire. *“Therefore, in 106, Trajan suddenly became rich enough to no longer need the money of his subjects, giving them something on top of that. However, the year 106 is the very year of the conquest of Dacia. Even if we don't have any document that tells us this, we have to admit that Trajan took the sums from Dacia that he then offered to the Romans, instead of asking them from them”*, says Jérôme Carcopino.

Trajan admired the courage of the Dacians in the two wars, decorating the Forum in Rome with about 100 of their statues. It is the only instance in history of a victor honouring his vanquished in this way, many statues being carved from red or cherry-red porphyry brought from Africa and Asia Minor, a hard volcanic rock intended only for Roman emperors or deities.



Fig.2. Reconstitution of Trajan's Forum [3, page 23]

The forum no longer exists today, but its image has been reconstructed by American historians and architects. The Romans had an attitude of respect and consideration for these redoubtable warriors and their people, the Dacian statues being placed in the attics of the porticos of the inner courtyard. Some are still preserved in large museums in Rome, Florence and Paris, but also in Spain and Germany.

2. The theft of the Dacians' gold by the Romans [4]

Of course, Decebalus had taken care to store his treasure in a safe and hard-to-reach place. Referring to this hiding place, the Roman politician and historian of Greek origin Cassius Dio (155–235) writes the following: *“The treasures of Decebalus were also discovered, though hidden beneath the river Sargetia, which ran past his palace. With the help of some captives Decebalus had diverted the course of the river,*

made an excavation in its bed, and into the cavity had thrown a large amount of silver and gold and other objects of great value that could stand a certain amount of moisture; then he had heaped stones over them and piled on earth, afterwards bringing the river back into his course. He also had caused the same captives to deposit his robes and other articles of a like nature in caves, and after accomplishing this had made away with them to prevent them from disclosing anything. But Bicilis, a companion of his who knew what had been done, was seized and gave information about these things” [5, Book LXVIII, 14, 4-5].

Much of the work of Cassius Dio has been lost, and the chapters describing the Dacian wars with the Romans have come down to us from the Byzantine monk Ioannes Xiphilinos, who lived in Constantinople in the second half of the 11th century. He divided the work into several sections, each containing the life of an emperor, but he also modified the original text, through his own omissions or additions. The account of Decebalus' hoard may have been added by Xiphilinos, as it is improbable that it was hidden in a river whose name does not appear in any other document.

The legend of hiding the treasures under flowing water circulated in antiquity, being also related by Diodorus of Sicily, who tells that the king Audoleon from the north of Macedonia did the same, hiding his treasure under a river with the same name – Sargetia! – around 300 BC, to protect him from the Thracian king Lysimachus, with whom he was in conflict.

From the account of Cassius Dio, we consider it plausible that the treasure was hidden in caves located as close as possible to Sarmisegetuza. Decebalus hid his treasures very wisely, and Trajan discovered them only by treachery, whether the secret was revealed by Bicilis or by the Dacian prisoners who appear in a scene on the Column. The fact that the treasure was hidden in the surroundings of Sarmisegetuza is confirmed by the scene CXXXVIII on the Column (Fig. 3), which shows the loading of the precious metals on a mule, in a mountainous and wooded area, as shown by the account of Cassius Dio, in the part her plausible.



Fig.3. Scene CXXXVIII on the Column

Pannons, Greeks or miners of oriental origin, mentioned in the inscriptions from Ampelum and Alburnus Maior, also worked in the gold mines of Dacia.

As a result of the use of local miners and colonists, mining experienced a flourishing era in the area of the Apuseni Mountains, until the fall of 167, after the start of the first Marcomanic war (167–175). The Marcomanni were a Germanic tribe, related to the Suevi and the Lombards, who started two wars against the Roman Empire (167–175 and 178–180). In the fall of 167, they reached Ampelum and Alburnus Maior,

The idea of hiding the Dacian treasure under the water of the Strei Valley is also rejected by the great historian Nicolae Iorga: *“In the last mountain shelter, after he had hidden in the caves, and had not sunk under the waters of the Strei Valley, at least part of the treasures collected for a long time, he [Decebalus] laid the last meal of his only companions, who together sipped the liberating drink of death and then killed himself alone with the sword”* [6, page 152].

Trajan needed labourers in the depopulated territory of Dacia, so he immediately colonized this territory with people displaced *“from all parts of the Roman Empire”* (Cassius Dio), an almost unique case in the time of the Roman emperors.

The colonization was fast and massive, because the Romanians wanted to exploit as quickly and efficiently as possible the rich economic resources of the Dacian soil and subsoil. Dalmatians from the *Pirustae*, *Baridustae* and *Sardeates* tribes were colonized in Bucium and its surroundings, and in Roşia Montană, Pirusti and Illyrians were brought, who had learned the art of mining from the Greeks, all of whom were assured certain advantages. The colonists founded settlements called *vicus* and *castellum*, in such large numbers that they formed a separate corporation headed by Celesenius Constans, to whom the governor Opellius of Sarmisegetuza erected a tombstone at Ampelum, where he died (*Corpus Inscriptionum Latinarum*, III, 1322). Along with Dalmatians and Pirusti,

destroying the mining area and looting the gold and silver. The loss was so great that other settlers had to be brought in to work the mines. The Marcomanni were defeated by the governor of Dacia and Upper Moesia, Marcus Claudius Fronto (168–170), to whom the citizens of Sarmizegetusa erected a statue with an inscription praising his valour (*Corpus Inscriptionum Latinarum*, III, 1457). The great German historian and archaeologist Theodor Mommsen (1817–1903), a good connoisseur of the history of the Roman Empire and the coordinator of the monumental work in 12 volumes *Corpus Inscriptionum Latinarum*, is of the opinion that the inhabitants of Roşia Montană hid most of their wealth from the face of the Marcomanni invaders in secret places, known only to them. Mommsen is right; the same inhabitants will do the same in the next thousand years, when the barbarian peoples will invade them.

Emperor Trajan was not only a good military strategist, but also an excellent administrator of the empire. His personality harmoniously combined a series of qualities, such as kindness, justice, temperance, political decency and nobility, which attracted the admiration of his contemporaries and successors, being among the greatest, bravest and wisest Roman emperors.

For the safety of the province, Trajan stationed four legions here, later reaching 30 – 40 thousand soldiers (10% of the Roman army). The mining area of the Apuseni Mountains, which was of major interest to the Romanian authorities, was entrusted to the 13th Gemina Legion, based in Apulum, the most important military unit out of the four located in Roman Dacia. The Roman army consisted of legions and auxiliary troops. The legion had 4,200 – 6,000 men, all Romans citizens, divided into cohorts, maniples and belts. The auxiliary army consisted of pedestrians (*cohors*) and horsemen (*alae*) who did not have Roman citizenship. After 25 years of military service in the auxiliary troops, the fighters were left at home, received Roman citizenship, were given land and started families, marrying Dacian women. Also, many veterans from the legions, after being discharged, settled either in urban centres (Apulum, Potaissa, Napoca, Ulpia Traiana, Ampelum) or in the countryside. It is estimated that during the 165 years of occupation, around 82,500 veterans settled in Roman Dacia, almost a quarter of them from the XIII Gemina Legion, stationed at Apulum, until the Aurelian retreat.

The first governor of Roman Dacia, named *legatus Augusti pro praetore*, was Decimus Terentius Scaurianus (106 – 111), during which the new capital of the province, *Ulpia Traiana* (108 – 110), was founded near Haţeg. The Roman administration divided the settlements in Dacia into three large categories: colonies, municipalities and villages. Apulum will become a colony, and Ampelum, a municipality. They were led by a council (*ordo decurionum*). The area of the Apuseni Mountains was considered a territory of special interest and passed into the emperor's patrimony (*patrimonium Caesaris*), due to the riches of the underground. The area was administered by a *procurator aurariarum*, based in Ampelum which, due to its geographical position, was in the centre of the mining region, facilitating movement and control over gold and silver production. All the revenues obtained from the exploitation of gold and other metals entered the Caesar's treasury. The prosecutor was appointed directly by the emperor of Rome, being a trusted man of his. He had under him a whole army of officials who watched over the smooth running of the mining, making sure that not a single gram of gold was stolen: *tabularii* (archivists), *adiutores tabularii* (helpers of the archivists), *decurii* (officials who solved local mining problems), *triumvirii* (group of three people employed at the gold smelters), *dispensatores* (cashiers), *verna subsequens librariorum* (mining foremen), *librarians* (tax agents), *questorii* (collected the gold owed to the state as tax), *auri lustratis coactor* (money changers gold), *vilicus* (state official), *scribii* (they kept records of all mining works), *collegium fabrorum* (blacksmiths who made and sharpened the tools needed by the miners) and *collegium aurariarum* (the college or corporation in Ampelum which was responsible for the mines and collected the rent of the mines).

Among the mines exploited by the Romans, we mention the main ones from Roşia Montană, Bucium, Baia de Aries, Băiţa, Ruda and Stăniţa, but also the less important ones from Baia de Criş, Tebea, Căinelu de Sus, Căraci and Techereu. They were certainly exploited by the Dacians, because the Romans just didn't start doing geological surveys! All these localities are part of the Metaliferi Mountains chain. Trajan organized a line of military defence of the gold region, with a length of about 150 kilometers, for the safe exploitation of gold and silver. In addition to the mentioned military area, the Romans also exploited gold and copper from other localities, such as Sasca Montană and Moldova Nouă, in the southern area of Banat. During the Roman rule, which included the entire Danube Gorge, Moldova Nouă was an important mining settlement, a fact attested by the discovery, in 1985, near Ogaşul Băieşului, of the ruins of a Roman building with an area of 392 m², with living spaces and workshops metallurgy for melting and processing metals.

Guarding the gold mines and public order were entrusted to cohorts of the XIII Gemina Legion, which had permanent garrisons at Ampelum and Alburnus Maior. A cohort had a workforce of about 500 people and was led by a prefect. The Romans built fortified military camps called *castres*, which housed these

troops, having a defensive role. They also built settlements for miners and mines supervisors. After the war with the Marcomanni, Marcus Aurelius also brought the 5th Macedonian Legion to the region, based in Potaissa, to protect the access from the north of the Metalliferous Mountains.

We find much written information about the organization of mining in the Apuseni Mountains from the famous *wax tablets* from Roșia Montană, discovered in the old Roman galleries, in the period 1786 –1855. These are small wooden boards, tied two (diptychs) or three (triptychs) and covered with beeswax, on which different texts were written. In total, 40 tablets were discovered, but only 25 of them were preserved, 4 being complete triptychs. They come from the time of the Roman emperors Antoninus Pius (138 – 161) and Marcus Aurelius (161 – 180), and one comes from the time of the emperor Hadrian (117 – 138). The texts of the tablets represent loan contracts, contracts for the sale and purchase of slaves, labour and association contracts, receipts, contracts for the lease of mines by individuals and associations with a view to their exploitation, an act of dissolution of a funeral college and a list of dishes for a guest of a college of craftsmen. Their analysis made it possible to nuance the functioning mechanisms of applied Roman law. As a separate fact, at the feast that took place on the eve of the calends of May, i.e. on April 30, the amount of wine consumed represented more than half of the total expenses. The contracts were drawn up in Alburnus Maior, Apulum or in other localities that could not be identified.

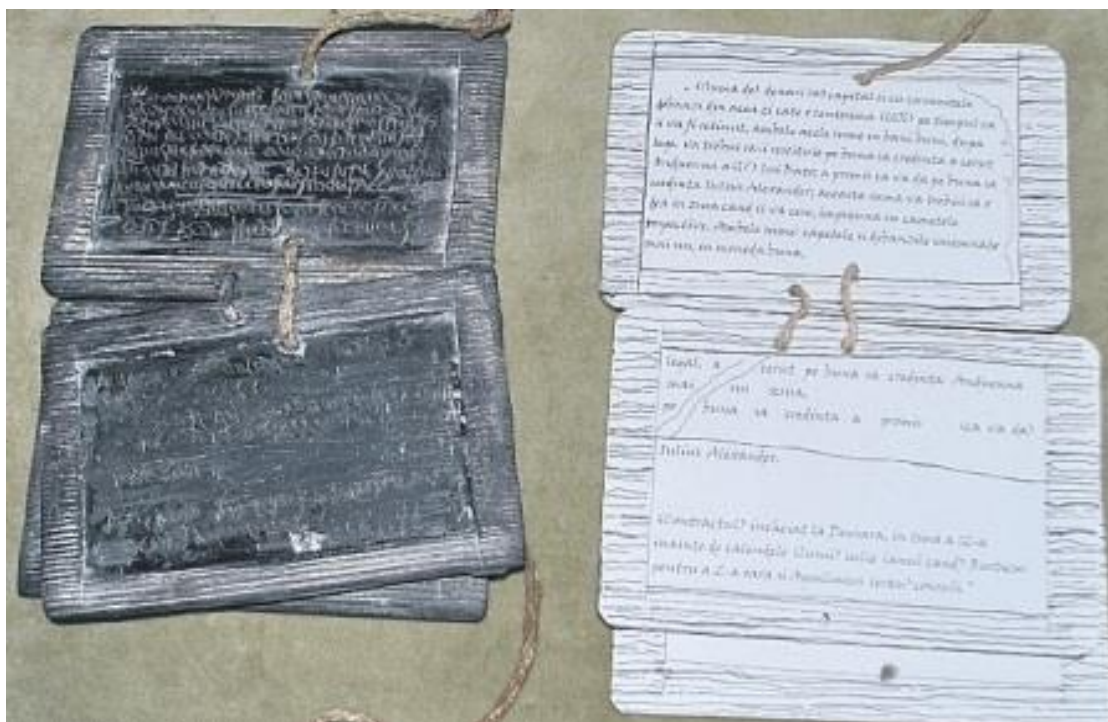


Fig.4. Triptych wax tablets that closed like a book

The exemplary organization by the Romans of all social-economic activities led to a flourishing state of the area. Mining, crafts, agriculture, trade and even the arts brought prosperity to the inhabitants, developing to such an extent that under Emperor Hadrian this province was called *Dacia Felix* (Happy Dacia). The riches of the underground and the well-being of the inhabitants attracted the attention of the surrounding peoples, so that all the Roman emperors after Trajan took measures to preserve and defend the province.

Among all of them, we should mention Septimius Severus (193 – 211), a Berber born in North Africa who visited the gold regions of the Apuseni Mountains in the first year of his reign, when he awarded medals to the legions from the Danube that helped him to ascend the throne, including the 13th Gemini Legion. And Severus' son and successor to the throne, Caracalla (211 – 217), visited the mining region of the Mountains, and in 212 he issued the edict *Constitutio Antoniniana*, by which all free inhabitants of the empire became Roman citizens. The following emperors were more and more unworthy, living in orgies and debauchery. The history of almost a millennium of the proud empire was coming to an end. Taking advantage of Rome's weakness, the Goth, Marcomanni and Sarmatian warriors attacked these rich lands, so that Aurelian (270 – 275), the 27th successor of Trajan, decided to withdraw the Roman legions and servants from Dacia, to south of the Danube, in a new province, called *Aurelian Dacia*. The territory liberated by the Romans was immediately occupied by the Goths, who ruled it for 100 years (271 – 380). During this period,

we witness the degradation of urban life and the retreat of the population to rural areas, which led to a significant economic decay. The theory according to which the entire population would have retreated to the south of the Danube is obsolete, not being taken into account by any serious historian.

The mining technology of the Dacians could not be reconstructed, due to the lack of edifying archaeological discoveries. Certainly, they exploited the alluvial gold by the same processes that were used until the Middle Ages, and even later. The gold veins in the mountainous areas were washed away by the waters, and the pieces of ore detached from the vein were carried downstream for great distances and shattered. Those who searched for gold nuggets in the alluvium used simple tools. Gold sand was collected from the riverbed with the hoe and barter and unloaded on the upper part of an inclined plane of boards, covered with a fabric made of fluffed wool, called *sluice-box*. With a wooden bucket, water was taken from the river and poured onto the sand on the ridges, to be drawn down onto the woollen fabric. To move the sand, a barrow was also used. After the woollen fabric retained the gold threads, it was washed in a tub with water, and the resulting gold was separated from the remaining sand with a *gold pan*.



Fig.5. Mining of alluvial gold [7, page 113]

It is hard to believe that the huge amount of gold accumulated by the Dacians came only from alluvium. Going up the course of the waters, they discovered the outcrops of their gold veins, starting their exploitation, first on the surface, and then underground. The Dacian mines were not as developed as those of the Iberian Peninsula or Britannia, being probably narrow coastal galleries with short lengths or shallow shafts dug in veins. As I mentioned, it has been scientifically proven that the Dacians mined underground gold before the arrival of the Romans.

The conquest of Dacia by the Romans also meant the improvement of gold extraction and processing technology. The Romans were not satisfied only with taking over the mines and miners from the Apuseni Mountains, but also brought the technique used in those times in the main mining centres of the empire, as well as skilled miners. The most interesting vestige of Roman surface mining in the Apuseni Mountains is at Bucium, where the Romans dug a trench called *Ieruga*, on the outcrop of the vein of the same name, very rich in gold. Its length is 500 m, and its depth is 20 m at the top and 30 m at the bottom. The width at the base is 15 m at the top and 20 m at the bottom. This work is a faithful copy of the *hushing* (*ruina montium*) in Spain, seen and described by Pliny the Elder in *Naturalis Historiae*. As in Spain, a 120×120 m lake had been set up at the foot of Corabia, which corresponded to the 200×200 paces lake described by Pliny, the water being necessary for the selection of gold from the ore ground in the mills. It is estimated that the Romans extracted about 4 tons of pure gold from here. Today the area is wooded, but in a photo taken around 1900, this Roman mining work can be seen very clearly.



Fig.6. The hushing dug by the Romans on the southern slope of Corabia

Towards the end of the 19th century, in the area of the lake at the base of hushing, a mortar made of amphibole andesite and a stone made of quartz conglomerate were discovered, with which gold ore was crushed (Fig. 7). Next, the crushed ore was ground in stone mills. The concentration of gold was done by gravity, using for this purpose the water from the accumulation tank, which drove the ground product on an inclined plane similar to the sluice-box. The waste was washed and carried away by water, and the gold, being heavier, remained on the sheep's fur or the soft fabric on the inclined plane. In order to avoid the flow of the material on the sides of the inclined plane, it was provided with borders. The gold threads were then melted in refractory clay crucibles, placed in

the embers of an open-hearth furnace. The melt was, in fact, an alloy of gold and silver, which also contained other impurities. For the purification of gold, salt (NaCl) was introduced into the melt, which separated the gold from the silver, the process being described by the Roman historian of Greek origin, Diodorus of Sicily, in the century I BC. Pure gold and silver chloride were thus obtained. Silver chloride was mixed with lead oxide, from which the silver was then extracted through a process known today as *cupellation*.

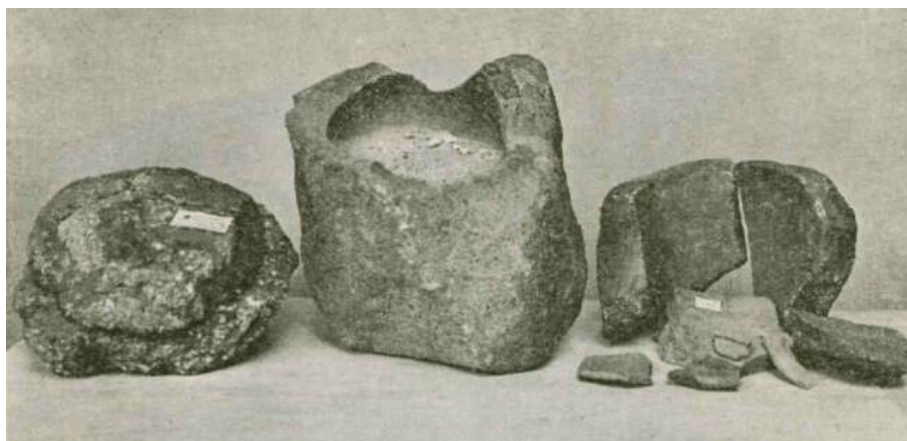


Fig.7. Roman mortar for crushing the gold ore discovered at Vulcoi Geological Museum of Hungary in Budapest

For underground mining, the opening of the mines was done through coastal galleries, dug from the surface. In the area of the deposit, the works were continued either with directional galleries, dug in the direction of the vein, or with transverse galleries. The galleries (*cuniculi*) were opened, as much as possible, in hard and compact rocks, digging was done with chisel and hammer. The directional galleries had heights of 2.1–2.7 m and widths of 0.9–1.2 m, depending on the size of the vein, and the transverse ones, heights of 1.5–1.8 m and widths of 0.6–0.65 m. If the rocks were stable, the galleries were not reinforced, but had a vaulted ceiling, for a better distribution of pressure on the side walls (Fig. 8. a). In the case of a weak ceiling, the reinforcement was done only with beams tightened with wedges and lined with boards (Fig. 8. b), and if the walls did not show sufficient strength, they were reinforced either with half-frames (Fig. 8. c) or with complete wooden frames (Fig. 8. d). The advance of the galleries in hard rock was done by executing a 200×200 mm square core, with a depth of 50–70 mm, in the centre of the cross section of the gallery, after which the cavity was enlarged to 400×500 mm and then to 700×900 mm (Fig. 9). Finally, the definitive contour of the gallery was dug, which was smooth and without cracks. This explains the fact that such galleries, such as those in Bucium or Roşia Montană, on the hills of Cetatea Mare and Cetatea Mică, have been kept in very good condition for almost two millennia. Also, the Romanian archaeologist Téglás Gábor described two galleries from Ruda – Brad, seen by him, one with a length of 160 m and another with a length of 650 m, both having a height of 1 m and a width of 0.6 – 0.7 m.

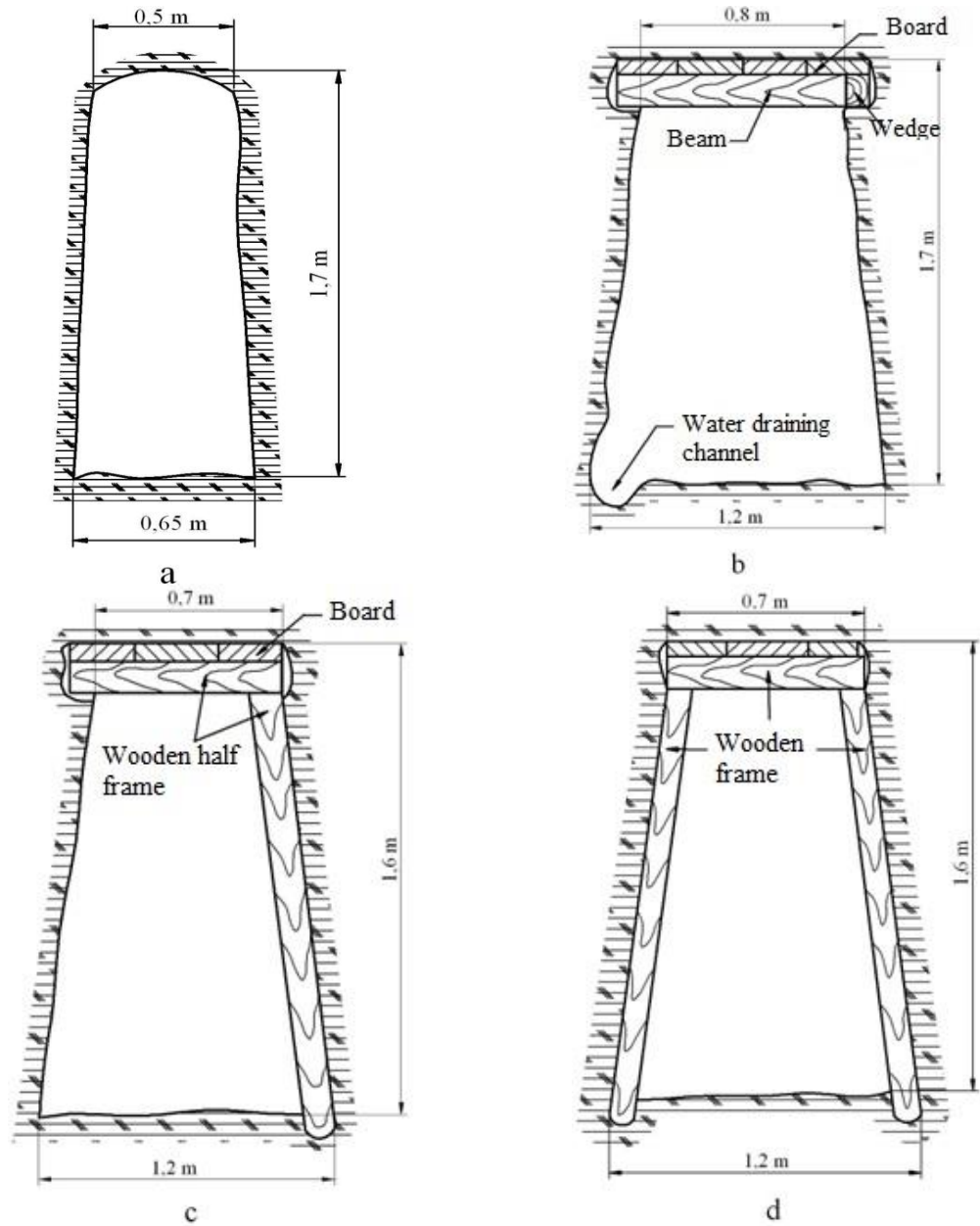


Fig.8. Types of Roman galleries [1, page 174]

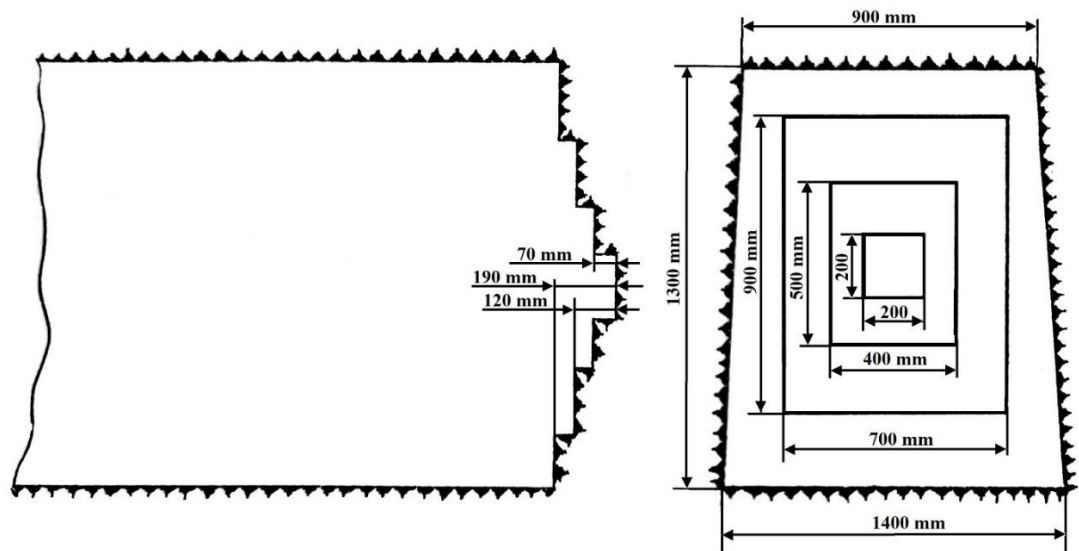


Fig.9. Digging a Roman gallery in hard rocks [8, page 64]

Such small dimensions of the galleries were often used in antiquity, as Diodorus of Sicily writes [Book III, XIII, 4]. In support of this statement, we recall that two of the waxed tablets from Alburnus Maior have as their subject the sale-purchase of two children, used as slaves in the underground. The girl (*puella*) Passia is bought by the Dalmatian Maximus of Bato, from the pirust Dasius of Verzo, for the sum of 205 denarii, and the boy (*puer*) Apalaustus is bought by the Dalmatian Dasius Breucus for the price of 600 denarii.

If the rock was very hard, *the fire and water method* was used. The first written mention of this ancient technique belongs to the Greek historian and geographer Agatharchides (2nd century BC), it was then found in the writings of Diodorus of Sicily. The rock was heated by fire to expand, then cooled by spraying water, which caused it to contract suddenly and crack or even crumble. In the same way, the endless expanses of sand were formed in the deserts, where the day it is very hot and very cold at night. From what was written by the ancient authors, it appears that vinegar was used instead of water, which had an even greater destructive power, due to the higher contraction coefficient.

As **methods of exploiting** the gold veins applied by the Romans in the Apuseni Mountains, we mention:
A – *Exploitation in ascending directional strips with goaf stowing* (Fig. 10) was used in areas with less hard rock, where the material was dislodged with chisel and hammer. The required amount of backfill was small, it could be produced even in the abattoir, by cutting the walls next to the vein. First, the raises *R1*, *R2* and *R3* were excavated, which followed the inclination of the vein, and were then joined by the *LG* lower galleries, to achieve natural ventilation. During the excavation of the raises and the foot drifts both tailings and gold ore were brought to the surface.

The exploitation of the *P1* panel started upwards, from the base, evacuating only the ore and using the tailings to fill the excavated space. At the level of each strip, the tailings were excavated first, the vein remaining on the wall of the abattoir and being later detached with the chisel and hammer, that is, selective exploitation was carried out. After the operation of panel *P1*, it was moved to the next panel *P2* and so on. Evacuation of the ore to the surface was carried out on sledges, with wooden baskets carried behind. For this, steps were dug into the rock or wooden ladders were mounted on the wall of the suite.

As can be seen from the old mining works discovered in Roşia Montană and the mines around Brad, the height of the panels reached up to 30 meters.

B – *Exploitation in downward directional strips without goaf stowing* was applied in the case of veins with large thicknesses, cantoned in hard and very hard rocks. Exploitation started right from the surface, in the outcrop of the vein, following its configuration in depth. The vein was extracted by making some grooves with a chisel and a hammer arranged along two directions perpendicular to each other, thus creating some squares of variable sizes that were carved. To avoid accidents, the exploited spaces were reinforced with wood.

C – *Mining with residual voids in descending horizontal slices* was used in areas with a dense network of thin veins, called *stockwork*. The opening of the deposit was made through a coastal gallery, which went all the way to the stockwork. Here, its exploitation began, on the entire surface, through descending horizontal strips. In this way, a huge cavity called *coranda* was formed. The gold ore was evacuated with wooden baskets carried behind, on an ascending serpentine dug into the walls of the cavity. Some started right on the surface, others developed only underground. From place to place, small coastal galleries or chimneys were dug for ventilation. Such ancient mining works were discovered in Roşia Montană and Bucium, some of them having impressive dimensions.

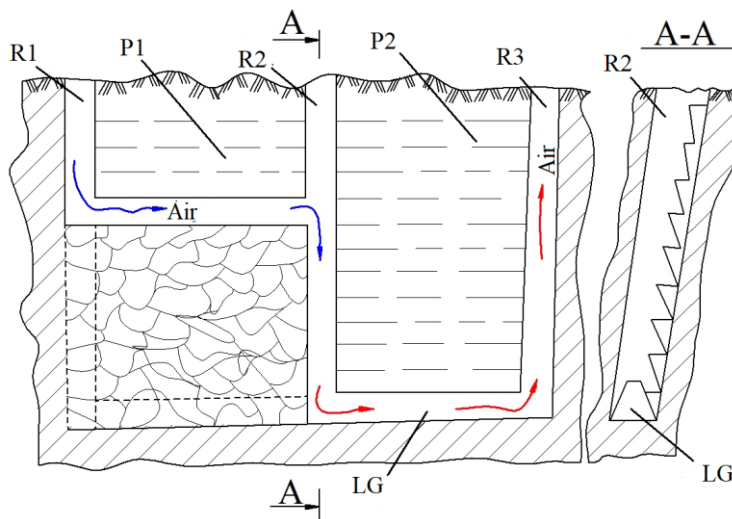


Fig.10. Exploitation in ascending directional strips with goaf stowing [4, page 69]

Of course, the ancient miners did not know the classification of gold mining methods presented above, but they applied these practices depending on the existence and inclination of the veins, the hardness of the surrounding rocks and the configuration of the land. They were always careful to ensure the avoidance of the surrounding rocks, the ventilation of the workplace and the evacuation of underground water. They thus created underground mining works that have endured to this day, without being supported by wooden reinforcements and without ever having been controlled.

Transporting the ore to the surface was done manually, with the help of reed baskets tied at the back. In the abattoir, a first selection of the useful tailings was made and only the useful ore was transported to the processing site. For the evacuation of the ore from the very narrow directional galleries, the *fotraga* was used, a wooden vessel obtained by hollowing out a tree trunk, with a length of 1.4–1.5 m and a width of 0.4–0.5 m. *Fotraga* it was pulled with a rope tied to the hook at the end of it. The loading of the material was done with a hand trough of wood. Both objects were found in a Roman gallery of the *Saints Peter and Paul* mine in Bucium, the trough being made of ash wood.

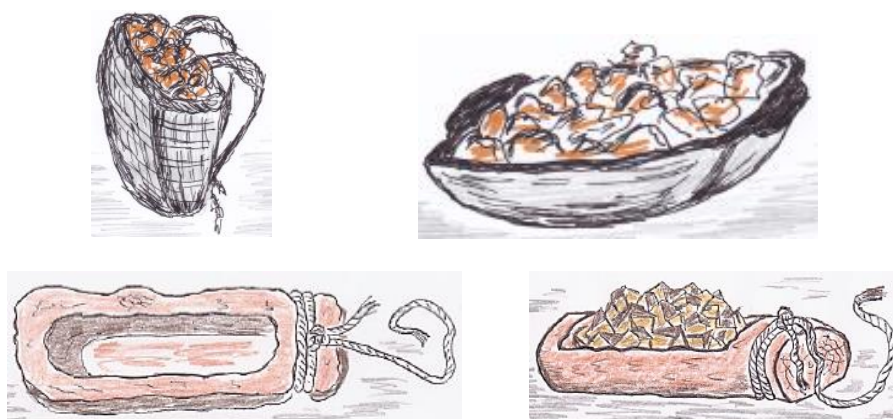


Fig.11. Basket, hand trough and fotraga for transporting gold ore [9, 10]

Evacuation of water was one of the difficult problems to solve in the technical conditions of that time, but since the first century of the Christian era, the Romans used two vertical water evacuation devices: Archimedes' screw (Fig. 12) and the hydraulic wheel (Fig. 13). The first device was invented by the great ancient scholar Archimedes (287–212 BC), as a military application, then being used to evacuate water from gold mines in Egypt and the Iberian Peninsula. It consisted of a wooden cylinder in which a helical screw rotated, with a wooden or copper propeller. The auger was turned by hand with a crank. The device, discovered in the Roman gold mines of the Iberian Peninsula, had lengths of 3–5 m and inner diameters of 20–30 cm.

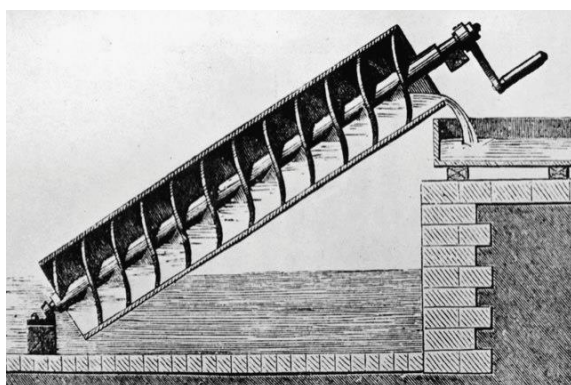


Fig.12. Archimedes' screw

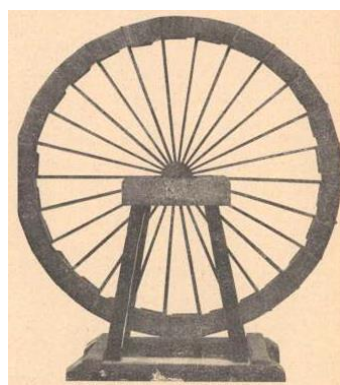


Fig.13. Hydraulic wheel

The water wheel resembled a mill wheel, having a spoked shaft and an outer rim with a diameter of 4–6 m, on which 20–24 buckets sealed with pitch and wax were mounted. The buckets lifted the water from a lower basin and poured it into an upper basin, through an adjacent trough. The operation was repeated vertically, up to a coastal gallery equipped with a drain. The wheel was operated manually, with the help of handles mounted on the outside of the rim or by stepping on the feet, by one or two people, from a frame mounted on the upper part of the wheel. My water lifting height was 3/4 of the diameter of the wheel, and the

flow reached 70–80 litres per minute. The description of water wheels was made by the Roman architect Vitruvius (1st century BC), some examples being found in the Iberian Peninsula, Great Britain and in Romania, in Roșia Montană and Brad, ensuring the evacuation of water on a height of 30 meters (Fig. 14).

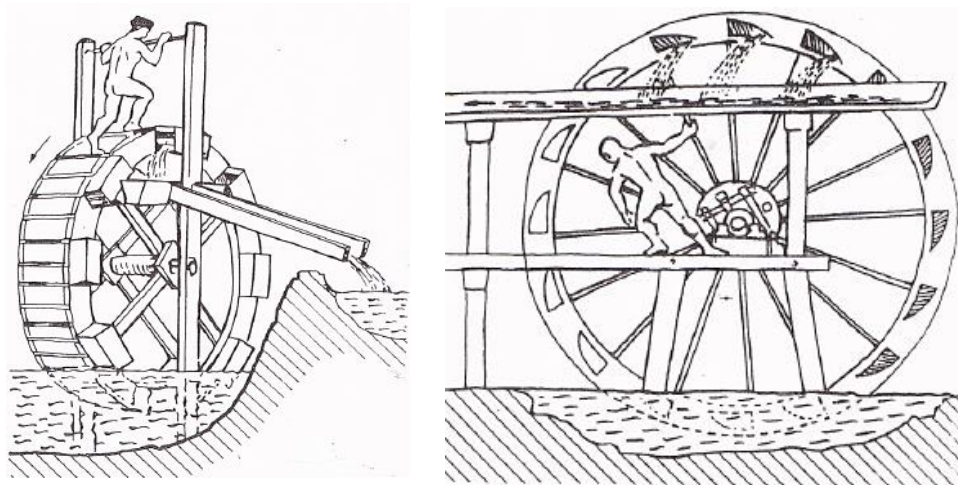


Fig.14. Working principle of hydraulic wheel [9, page 153]

The ventilation of the mines is done by convection, that is, by a vertical movement of the air, due to the lower density of the warm air in the mine, compared to the higher density of the cold air outside. Ventilation was absolutely necessary where fire and water were used, for the evacuation of smoke and water vapor. It was realized by digging an overlapping gallery, at a distance of 4–5 m from the base gallery and joining the two galleries with ventilation ducts. The clean air entered through the main well, and the contaminated air exited through a secondary well, at the mouth of which a fire was lit to increase the depression. The ventilation ducts were dug at distances of about 10 meters. After digging a follower, the ones in front of it were blocked, so that the clean air was not discharged through the ventilation gallery, but was led to the work front. Such works were described by several ancient authors (Lucretius, Vitruvius, Strabo and Pliny the Elder), being then discovered *in situ* at Rio Tinto, in Spain. The suites and the ventilation gallery had small sections, about 1 m². According to Pliny's description, checking the air was done with an opiate; if it went out, the workers were evacuated and measures were taken to improve the ventilation.

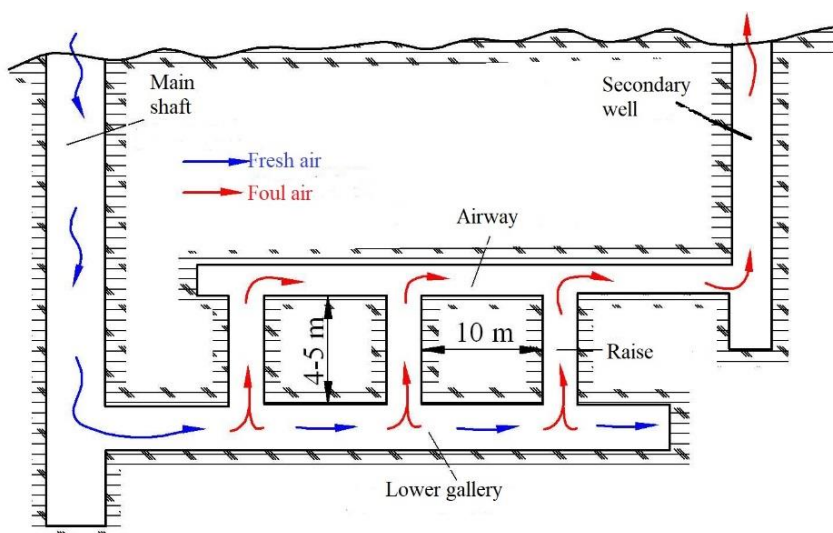


Fig.15. The ventilation of a Roman mine [1, page 177]

The lighting of the mines was done with earthen lamps (*lucernae*). The lamp was made of burnt clay and lit with the help of a wick inserted in a container wick with tallow, lard or oil. The tank could be open or closed. In the second case, the tank was provided with a hole for the introduction of fuel and 1–3 holes for removing the wick. The mark was always applied to the bottom of the tank and represented the name of the manufacturer. For handling, the earthen lamp was provided with a handle. He usually sat in specific niches dug in the walls of the galleries. Pliny the Elder writes that the earthen lamps were also used to measure the duration of work, probably of a day or a shift of 8 or 10 hours.



Fig.16. Earthen lamps for mine lighting [1, page 177]

As I mentioned, the Romans captured 165.5 tons of gold and 331 tons of silver from the Dacians, and during the 165 years of occupation they extracted another 450 tons of gold and 900 tons of silver. After the withdrawal of the Romans from Dacia, the entire course of social-economic life took on a rural character. The economy returned to shepherding and agriculture, and crafts declined, taking on a preponderant household character. After the withdrawal of the Romans, the mining activity of the native population was reduced to the level of using metals for the manufacture of agricultural tools, weapons and household items. Gold mining in the Apuseni Mountains was probably reduced to the exploitation of alluvial gold from the riverbeds and to the exploitation of poorer veins closer to the surface that had not been important for the Romans. It is hard to believe that the miners who remained here after the departure of the Roman administration abandoned their work. Gold and silver constituted a strong currency even in those troubled times, about which we know almost nothing.

The mining technology of the Romans was so advanced that for the next 1,500 years it remained almost unchanged, not only here, but throughout Europe.

References

- [1] **Bolunduț I.L.**, 2017
Monografia comunei Bucium – Alba, Editura ALTIP, Alba Iulia.
- [2] **Carcopino J.**, 1924
Les richesses des Daces et le redressement de l'Empire Romain sous Trajan, Dacia No. 1/1924, pp. 28 – 34.
- [3] **Velcescu L.**, 2007
Représentations statuariques du roi Décébale, SCIVA, Tom 58, Nr.1–2/2007
- [4] **Bolunduț I.L.**, 2023
Istoria aurului românesc, Editura Cognitiv, Alba Iulia.
- [5] **Cassius Dio**, 1925
Roman History, Published by Loeb Classical Library, USA.
- [6] **Iorga N.**, 1936
Istoria Românilor • Sigiliul Romei, București.
- [7] **Nichitean C., Jianu C.M.**, 2004
Din istoria extragerii aurului aluvionar, Sargetia, Nr. XXXII/2004, pp. 85–120.
- [8] **Maghiar N., Olteanu Șt.**, 1970
Din istoria mineritului în România, Editura Științifică, București.
- [9] **Rus V.**, 2019
Alburnus Maior/Roșia Montană • Monografie minieră, Editura Cognitiv, Alba Iulia.
- [10] **Rus V.**, 2021
Micii producători de aur de la Roșia Montană, Editura Cognitiv, Alba Iulia.



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