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ROMAN MINING ROADS IN CENTRAL BALKANS: CASE STUDIES OF KOSMAJ AND KOPAONIK MOUNTAINS

Abstract: The economic organisation of mining and metallurgy in Central Balkan provinces refers not only to administrative settings and technological achievements but also to the whole system of establishing the life of the bearer of this economic branch. One of the critical segments of this system was the construction of roads of varying degrees of importance. In this paper, parts of a periphery infrastructure network, which can also be called mining roads, will be considered. Historical sources generally do not provide information about them, so archaeological recognition of recent landscapes is the only source available. These are the routes from which the ore was brought from the mine to the metallurgical centre and the administrative point where it was measured, marked and prepared for further transport. The study was conducted as case studies in the northern part of the Ibar domain within the *metalla Dardaniae* and the Kosmaj domain in the *metalla Tricornensia*. The obtained results provide a closer insight into the way the raw material is transported through perception and landscape change by the imperial authority: what were and where were the roads, the duration and the stages of transport, and whether the transport included the mining district as the place of preparation of the metal for the further transport, cost-effectiveness of a particular mode of transport, communication between the defined structures within the mining domain, the possibility of using a *villa/vicus* as an administrative point or a workshop, among other aspects of infrastructural and logistical organisation.. The research also included an examination of long-distance transport routes, proposed in earlier literature, to review previous assumptions about their role in the transportation of ores and metals to Rome, using GIS for a more detailed analysis. Finally, the study highlights the settings that changed throughout antiquity in this area following the political changes in the Empire.

Keywords: *metalla*, mining road, long-distance transport, GIS analysis, Kosmaj, Kopaonik, Moesia Superior, antiquity

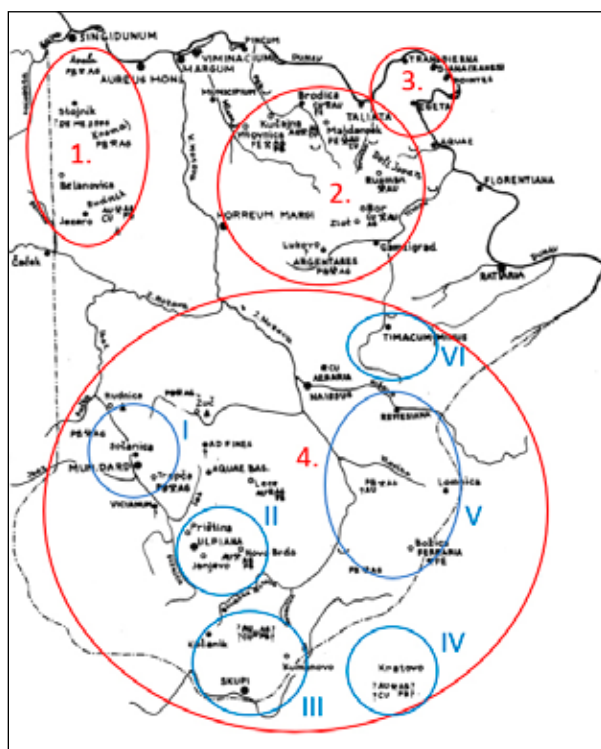


Fig. 1. Mining areas in Moesia Superior according to Dušanić (1. *metalla Tricornensia*, 2. *metalla Pincensia*, 3. *Civitas Moesorum* and 4. *metalla Dardaniae*: I – Ibar domain, II – Janjevo domain, III – Kumanovo domain, IV – Kratovo domain (?), V – Remesiana domain and VI – Ravna domain

Сл. 1. Рударске области Горње Мезије по Душанићу (1. *metalla Tricornensia*, 2. *metalla Pincensia*, 3. *Civitas Moesorum* и 4. *metalla Dardaniae*: I – ибарски домен, II – јањевски домен, III – кумановски домен, IV – кратовски домен (?), V – ремесијански домен и VI – равански домен

The Roman imperial power occupied the territory of Central Balkans in the 1st century AD. The beginning of the rule marks the establishment of provinces and all levels of administration, the construction of infrastructure and defence system, the occupation of indigenous mines, the establishment of borders and so on, to secure a retreat for further conquest and organise a system that will bring economic benefits to the Empire. The main potential of this area lies in mineral resources, traditionally exploited by the indigenous population. Occupation of mines, formation of mining domains (fig. 1),¹ organisation of administrative control, employment of miners from different social layers, relocation of experienced miners from other provinces, and construction of supporting infrastructure were all part of a long and thoroughly designed process aimed at achieving an efficient and strictly controlled organisation of mining and metallurgy.

* This research was financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the framework of funding for scientific research at the University of Novi Sad Faculty of Philosophy (Contract No. 451-03-65/2024-03/200166, dated 5 February 2024).

¹ Map adapted from S. Dušanić, *Aspects of Roman Mining in Noricum, Pannonia, Dalmatia and Moesia Superior*, Band 6 Politische Geschichte (Provinzen und Randvölker: Lateinischer Donau-Balkanraum), edited by Hildegard Temporini, (Berlin and Boston 1977), 55 corrected by the authors; for domain division see Idem, *Организација римског рударства у Норичу, Панонији, Далмацији и Горњој Мезији*, Историјски гласник 1-2, Београд 1980, 25-28.

Therefore, when the first Roman legions arrived in the 1st century, work began on building Roman roads in the Central Balkans. Technological improvements helped create this network by utilising existing roads and constructing new routes in previously unreachable locations. Following general road construction guidelines, such as choosing the shortest route, avoiding steep slopes and deep valleys, keeping the route at higher elevations for better visibility, and avoiding straight lines whenever feasible, the Romans saw it imperative to connect potentially strategic regions. These roads enabled the movement of people and the transportation of raw materials and goods, ensuring the efficient functioning of social and economic activities. Some of these routes connected isolated mining regions to the global imperial road network, symbolising the integration of the provincial mining landscape into the Empire's broader administrative and economic framework.

Via metallica and Roman road network in Central Balkans

Historical sources provide a comprehensive insight into Roman roads, encompassing their construction, routes, stations, travel times, and other elements integral to a well-conceived and organised network. This network comprised roads classified by importance, as evidenced by administrative documents from the 1st century, attributed to the Roman land surveyor Siculus Flaccus.² During the 1st and 2nd centuries, the *viae* were adapted and expanded in response to the military activities in the newly organised province of Moesia Superior, as noted by classical authors. However, beyond this simplified view, other factors must be considered, such as improved governance in conquered territories and access to mining areas. The need for resources to support continuous military campaigns promoted the construction of roads to central mining regions, which were organised as well-known imperial mining domains. Following the definitive establishment of the provincial administration, *viae* were used for political management and tax collection. Furthermore, based on their administrative features, it is significant to distinguish among different types of roads: *viae publicae* - main roads financed and maintained by the state; *viae militaris* - secondary roads funded by the military and built for specific times and purposes; *viae vicinales* - local routes and *viae privatae*, lower-tier roads that completed the local road network, built and maintained by individuals.³

During early antiquity, when imperial domains were under the direct authority of the emperor, all proceeds from these domains directly went to the *fiscus* - building and maintaining a network of mining roads was the segment of the imperial agenda and duty of the state. In late antiquity, changes in the economic system occurred, so the activities of the imperial domain became the responsibility of local elites through leasing. Therefore, peripheral branches of the mining roads became a *viae privatae*. The responsibility for these roads shifted to the landowner who

² Sic. Flacc. XIX-XXI, 19. according to B. Петровић, *Дарданија у римским итинерарима. Градови и насеља*. Београд 2007, 25-26.

³ Ibid.; A. Sánchez Verdú, *Unearthing the Roads of Roman Hispania: Evolution of Theories, Methodologies and Value Enhancement Techniques*, International Journal of Student Research in Archaeology (IJSRA) 1/1, (March 2016), 15-16.



Fig. 2. The position of the discovered route within the Kosmaj *metalla* (Documentation of the National Museum of Serbia)

Сл. 2. Позиција откривеног пута у оквиру космајске *metalla* (Документација Народног музеја Србије)

constructed the road and bore all costs for its build and maintenance. The continued sustaining of the road network as a fixed legacy system is the most telling indicator of its fundamental importance to the infrastructure of the Roman economy.⁴

Settlements rapidly developed during the 2nd and 3rd centuries, driven by ore exploitation throughout the province. At that time, roads played a significant economic and commercial role. The wealth of mining potential and organised imperial exploitation facilitated the *long-distance transport* of metals to Rome and other parts of the Empire.⁵ In late antiquity, the state faced increasing threats from internal political problems and barbarian attacks on provincial borders. Consequently, *long-distance transport* gradually diminished, and economic activities concentrated within provincial borders. This shift coincides with the absence of products from Central Balkan mines throughout the Empire, dating back to early antiquity, as evidenced by the finding of *massae plumbeae*⁶ from the Tiber⁷, Sarmizegetusa⁸ and Caesarea Maritima⁹. These finds originated from the Central Balkans mines

⁴ Hitchner, R. B. *Roads, Integration, Connectivity, and Economic Performance in the Roman Empire*, Highways, Byways, and Road Systems in the Pre-Modern World, ed. S. E. Alcock, J. Bodel, and R. J. A. Talbert 2012, 226.

⁵ В. Петровић, *op.cit.* 111-112.

⁶ The *massa plumbea*, or lead ingot, represents the final product of metallurgy, consisting of pure metal suitable for transport and subsequent use in workshops. These ingots were utilised in producing plumbing systems, cookware, weights, medical instruments, and various other objects, as well as in construction. Such finds hold particular significance due to their stamped markings, which often provide valuable information. These inscriptions typically include the name of the owner or the individual responsible for the mine's exploitation, the origin of the ingot, its weight, and, in some cases, the intended use of the metal (e.g., Sarmizegetusa, see fn. 7), М. Марић, *Улога касноантичких вила рустика у организацији рударства и металургије на Централном Балкану*, докторска дисертација, Београд 2014, 57, фн 37.

⁷ S. Dušanić, *Iz istorije rimskog rudarstva u Gornjoj Meziji*, Arheološki vestnik Acta Archaeologica XXVIII, Ljubljana 1977, 167-172.

⁸ I. Piso, *La Mésie Supérieure et les débuts de Sarmizegetusa*, Römische Städte und Festungen an der Donau. Akten der Regionalen Konferenz organisiert von Alexander von Humboldt-Stiftung (Beograd 2003), ed. M. Mirković, Beograd 2005, 122-123.

⁹ S. Dušanić, *Roman mining in Illyricum: Historical aspects*, Dall' Adriatico al

that reached distant parts of the Empire thanks to roads (terrestrial, fluvial and maritime), which must be considered *via metallicae* in this context.

The term *via metallica* is not recorded as a specific, universal, or widely accepted designation for a particular road category by ancient authors. It is a descriptive term frequently used in academic literature to describe roadways transporting metal or ore.¹⁰ However, it is not a descriptive term used in scholarly literature to depict roadways that transport metal

or ore, although it does not initially describe a strictly defined category like *viae publicae* or *viae militares*. The term is generally used more flexibly to illustrate routes connecting mining centres to points for controlling territory and metal transport. Data about these routes are often speculative and presented using the natural logic of the most efficient connection between two structures within the mining landscape. It is because of their rare material preservation due to continued use during the medieval period and beyond, as further usage and maintenance works either negated or destroyed the original ancient structures.



Fig. 3. The geoarchaeological area of Suvo Rudište, including the Neveske Stolice site and recorded ancient roads (satellite map source <https://earth.google.com>, photo by M. Marić)

Сл. 3. Геоархеолошка област Суво рудиште са локалитетом Небеске столице и евидентираним античким путевима (сателитска подлога <https://earth.google.com>, фото М. Марић)

Case Studies of Roman Mining Roads in the Central Balkans

Today, knowledge of the dense road networks deployed by the Romans in the Central Balkans still needs to be improved. A comprehensive study on ancient roads has yet to be conducted in this region. However, information about these roads can be gleaned from sporadic surveys or documentation from institutions for cultural heritage protection. In addressing the issues of Roman provincial mining, researchers conducting numerous field studies have identified only a few paths that can tentatively be considered Roman mining routes. In this research, we have examined the *viae metallicae* as the most peripheral branches of the terrestrial road network that connect the mine to the metallurgical or administrative centre within the *metallum*.

Danubio-L'Ilirico nell'età greca e romana, Atti del convegno internazionale, Cividale del Friuli, 25-27 settembre 2003, Pisa 2003, 266.

¹⁰ Dušanić identifies the route *via Avala – Kosmaj – Rudnik – Sočanica* as a *via metallica*, explicitly designating it as a virtual path, see S. Dušanić, 1977, *op. cit.* fn. 178; Idem, *Mounted Cohorts in Moesia Superior*, Akten des XI Internationalen Limeskongresses, Székesfehérvár, Budapest 1977a, 239; Idem, *Army and Mining in Moesia Superior*, Kaiser, Heer und Gesellschaft in der Römischen Kaiserzeit. Gedenkschrift für Eric Birley, Stuttgart 2000, 343-363.

Mount Kosmaj and Metalla Tricornensia

The first example of a road originates from Kosmaj Mountain, the primary lead and silver source within the *metalla Tricornensia* (Fig 1.). This mining domain encompasses the region of present-day Šumadija, including the ore-rich deposits of the Avala, Kosmaj, and Rudnik mountains. The central zone of the Kosmaj mines spanned between the present-day villages of Guberevac, Stojnik, Babe, and Parcani, covering an area of approximately five km².¹¹ At the heart of the Kosmaj mine was the Roman *castellum* at Grad near Stojnik, manned by cohort *II Aureliae novae*. Additionally, the presence of the *vicus metalli*, presumably named *Demessum* or *Demessus*¹², suggests that the administrative centre of the imperial domain was established in this vicinity.¹³

The activity of the Kosmaj mines dates back to the period between the 1st and 4th centuries CE, based on epigraphic evidence. However, numerous other archaeological traces indicate habitation and the exploitation of mineral resources before establishing the imperial domain and after its decline. The material evidence that the scale of mining during antiquity remains, and mining operations targeting the region's rich mineral deposits are still visible across the Kosmaj mountain range. Later activities partially obscured these remains and, in some cases, completely devastated them. Additionally, the presence of Kosmaj metals in other parts of the Empire is corroborated by the 1879 discovery of a *massa plumbea* dating to the time around Alexander Severus' reign. This lead ingot was found near the Ripagrande harbour on the Tiber¹⁴, not far from Rome itself.

Long-distance transport, by which ingots were delivered to far-off parts of the Empire, followed terrestrial, fluvial and maritime paths, known mainly through written documents. However, there is a lack of written records regarding the local routes used to transport raw ore from the mines to the smelting sites and further to the distribution centres or the headquarters of the mining domain, where it was marked and prepared for onward transport. One such local route, connecting the exploitation site with the central settlement, was discovered on Kosmaj during one of the numerous field surveys.

Local foresters provided information regarding the existence of a path on the northeast slope of the hill. This trail, which has never been used for timber extraction, lacks a documented creation date; however, locals have historically employed it as the most convenient route for ascending the hill, given that the castle on the top of it is surrounded by steep slopes on three sides and is easily accessible

¹¹ Борић Брешковић, Б. & Црнобраја, А. *Остава сребрног римског новца из рудничке области Metalla Tricornensia*, Археолошко-нумизматичка студија, Београд 2015, 20-21; Црнобраја, Н. А. *Ревизионо археолошко рекогносцирање уже зоне римских космајских рудника*, Зборник Народног музеја – Београд XXIII/1, Београд 2017, 237-238.

¹² Diocletian's itinerary from 296, along with the content of this decree, indicates that *Demes* was identified as the headquarters of the Kosmaj mining district, see S. Dušanić, 1977. *op. cit.* 169, fn 71.

¹³ Idem, 1980, 35-37; Idem, 1977. *op. cit.* 167-172; Idem, 2003. *op. cit.* 10-11; Б. Борић Брешковић – А. Црнобраја, *op. cit.* 28-30; Црнобраја, *op. cit.* 240.

¹⁴ The find is preserved at the Baths of Diocletian in Rome; see S. Dušanić, 1977. *op. cit.* 167-172.

from the southwest.¹⁵ Following their guidance, the route was located, and its trajectory was recorded (fig 2.).

The path spans from the slag on the northwest slope at the Koševište ravine site to the slag on the southeast side of the hill, extending approximately 450 meters in length. Its width ranges between 1 and 2 meters, obscured by leaves and subjected to erosion processes. With elevations ranging from 225 to 235 meters and slopes of roughly 48%, the route stays relatively constant. On both sides, numerous open pits are beside the footpath, some resembling abandoned mineshafts. Additionally, 3 to 5 meters wide, several regular flats are situated below the path, descending slightly across the slope towards the Pruten stream. Given the spatial arrangement of depressions and flats, it is conceivable that they served as ramps for lowering ore. Despite crossing the only practical way to the castle, the documented route has never been marked on a topographical map or military section. Nonetheless, it remains the most accessible route today.¹⁶ Although it is difficult to establish a definite functional connection between the trail and the castle-mining complex at this level of research, the possibility of a connection should not be discounted.

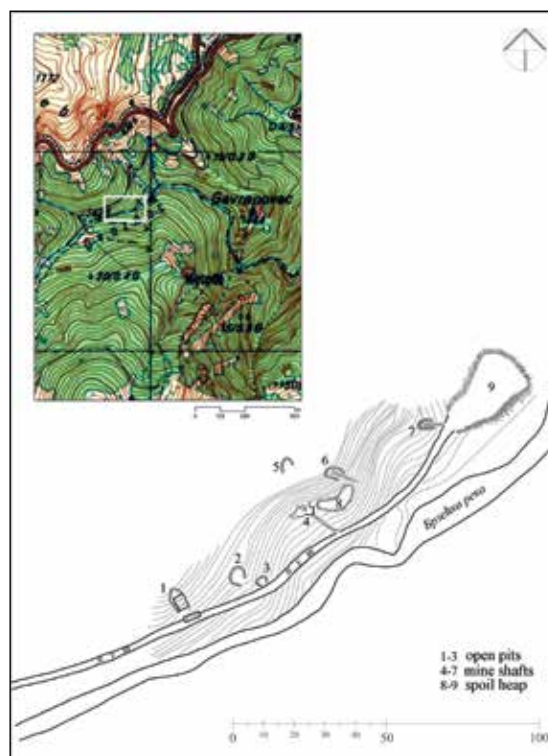


Fig. 4. The position and archaeological context of the mining and metallurgical site of Metode on Kopaonik (Documentation of the Institute for the Protection of Cultural Heritage in Kraljevo, drawn by A. Matović)

Сл. 4. Позиција и археолошка ситуација рударско-металуршког локалитета Метође на Копанику (Документација Завода за заштиту споменика културе Краљево, цртеж А. Матовић)

Mount Kopaonik and metalla Dardaniae

In addition to the Kosmaj silver mines, the most documented area in the literature belongs to the Dardanian mines, which were organised as an imperial tract of *metalla Dardaniae* (fig. 1). It extended across a vast area in the southern part of Moesia Superior, reaching as far north as the sources of the Pek and Timok rivers.¹⁷ Given the sizeable territorial expanse of mineral resources, the area

¹⁵ Црнобрња, *op. cit.* 242.

¹⁶ Idem, *op. cit.* 242-243.

¹⁷ The data on the Dardanian territory, where the Roman imperial authority would establish the imperial domain, can be found in historical sources such as Pliny the Elder, *Naturalis Historia* III, 149, and Ptolemy, *Geography* III, 9, 2.

was divided into at least five domains to establish efficient administrative control over the mines and organise their exploitation.¹⁸ The products of these mining sites were also found throughout the Empire, such as lead ingots transported to Sarmizegetusa¹⁹ during Trajan's reign and to Caesarea Maritima,²⁰ as indicated by the provenance seals on them during Domitian's rule. In addition to epigraphic inscriptions, recent lead isotope analyses have confirmed the use of metal from the Kopaonik area in the construction of the fortifications and later the city of Novae in the province of Moesia Inferior during the 2nd and 3rd centuries.²¹ Written sources have identified the primary roadways used to transport those metal findings in remote regions of the Empire. However, the local routes by which ore was transported from the mines to central settlements in this area still need to be discovered.

In that light, the following two examples of local mining roads originate precisely from the Dardanian area, specifically within the Ibar domain (fig. 1). This mining region spans along the right bank of the Ibar River, stretching from Trepča in the south to Stolovi and Goč in the north.²² It encompasses the mining slopes of Kopaonik on the right bank of the Ibar River and the Golija and Rogozna mountains on the left bank.²³ The epicentre of the mining region is situated in the village of Sočanica, which covers all Roman settlements in the vicinity, including *vicus metalli*, as the headquarters of the *coloni argentarium* and the mine administration,²⁴ the *Municipium Dardanorum*, the military station(s), and the settlement of the *peregrini civitates*.²⁵ Epigraphic inscriptions from this site bear witness to the presence of mine procurators since the early Empire.²⁶ The primary product extracted from these mining areas was silver associated with lead-zinc, iron,

¹⁸ С. Душанић, 1980. *op. cit.* 26-28.

¹⁹ I. Piso, *loc. cit.*; S. Dušanić, 2003. *op. cit.* 257, fn. 51; Idem, *Просопографске белешке о рударству у Горњој Мезији: породице имућних досељеника на рудничком тлу*, Старијар LVI, Београд 2006, 87; A. M. Hirt, *Imperial Mines and Quarries in the Roman World. Organisational Aspects 27 BC – AD 235*, Oxford 2010, 64, fn 76.

²⁰ Six lead ingots were discovered in 1993 within the remains of a sunken Roman ship, see S. Dušanić, 2003. *op. cit.* 266; Idem, 2006. *op. cit.* 87-89.

²¹ J. Reclaw, P. Siermień, J. Karasiński, G. Kamenov, W. Powell, B. Marciniak-Maliszewska, M. Kałaska, M. *The origin of lead artifacts from Novae: applications of Pb isotopes in identifying the provenance of Roman artifacts from N. Bulgaria*. Heritage Science, 12 (1), 2024, 12-40; M. Marić, *Opportunities and Challenges with the Protection of Ancient Mining Sites in Mountain Landscapes: A Case Study of the Kopaonik*, Journal of Mining and Metallurgy, 60 A (1) (2024), 14.

²² In earlier literature, the village of Rudnica on the western slopes of Mount Kopaonik is identified as the northern boundary of the Ibar mining district, based on an epigraphic inscription referencing the burial of a wife of the centurion *officinarum*, see С. Душанић, 1980. *op. cit.* 28, while recent research has shown that the northern boundary of the Ibar mining district extends along the West Morava River valley, see Марић, М. *Касноантичка купатила у рударским доменима: нова истраживања на Гоцу*, Зборник Народног музеја – Београд XXIII/1, Београд 2017, 293-295.

²³ Eadem, 2014. *op. cit.* 91.

²⁴ С. Душанић, 1980. *op. cit.* 28.

²⁵ Idem, *The Princeps Municipii Dardanorum and the Metalla Municipii Dardanorum*, *Živa antika* 54, 2004, 5.

²⁶ Idem, 1980 *op. cit.* 28.

and indications of gold prospecting in certain rivers and mountain streams. Notably, Kopaonik has the highest concentration of ore extraction and processing sites, including discovering mining routes at the Suvo Rudište and Metode sites.

The Suvo Rudište geoarchaeological complex extends across a vast expanse of the flat terrain on Kopaonik, situated below the Peak of Pančić. Ancient mining remnants are scattered throughout the entire area (fig. 3). Towards the east and southeast of Suvo Rudište lies an extensive mining part adorned with numerous remains of ancient infrastructure, predominantly open pits, clustered around Caričine strane, Vojetina, Kamenica, Belo Brdo, Marušić, and Zaplanina.

Their highest concentration (hundreds) was documented southeast of the Neveske stolice (fig. 3). This archaeological site, positioned at an altitude of 1800 meters, revealed the discovery of a sacral building from the 5th-6th century, along with a late antique military structure dating back to the 3rd-4th century.²⁷

In this area, analysis of aerial photography unveiled a plethora of paths traversing the mining area, interconnecting features on the Neveske stolice site with remnants of ancient mining operations scattered across the mountain (fig. 3). The results of archaeological field surveys have concluded that the current road linking the modern tourist complex to the site represents the sole pathway for accessing the area, following the natural contours of the terrain with minimal resistance. Given the vegetation characteristics in this area of flat Kopaonik, alternative routes would likely be discernible in aerial photographs. However, the specific, chronologically sensitive evidence of road construction that could provide substantial clues to the precise dating of these routes has not been determined through reconnaissance. This local road exhibits remnants of construction made from smaller stones in certain sections. However, the original structure has been destroyed mainly due to continuous usage up to the present day, coupled with numerous maintenance works. Most of these routes are not displayed on topographic or cadastral maps. The primary evidence attributing them to the Roman period is their association with the Roman site of Neveske Stolice and the ancient mining infrastructure in the vicinity.

Another significant site for our study is Metode, situated on the eastern slopes of Kopaonik, forming part of a well-maintained hiking trail within the first level of nature protection area in the National Park. Although remnants of ancient

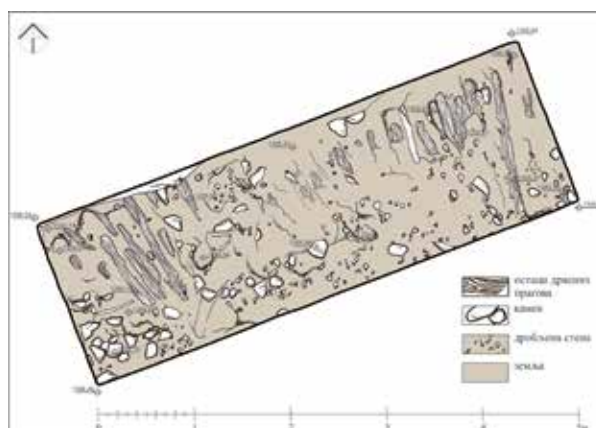


Fig. 5. The excavated section of the mining road at the Metode site (Documentation of the Institute for the Protection of Cultural Heritage in Kraljevo, drawn by A. Matović)

Сл. 5. Истражени део рударског пута на локалитету Метође (Документација Завода за заштиту споменика културе Краљево, цртеж А. Матовић)

²⁷ M. Marić, 2024. *op. cit.* 14.

mining and metallurgy are located directly along the recent hiking trail, they are not included in its informational content. Field surveys have revealed the presence of mineshafts, open pits, spoil heaps, mining pathways, and potential locations for ore refining and smelting based on slag findings (fig 4.). For this topic, we will focus solely on the identified segment of the route, measuring approximately 500 meters in length and around 2 meters in width. The roadway is constructed atop a sturdy rocky surface. In the part of the route, the surface layer consists of wooden beams arranged transversely to the track, running parallel to each other along the road. A section of the mining road was excavated as part of the site's archaeological excavations during the summer of 2022.²⁸ The results indicated that the wooden beams were preserved only in one segment (fig. 5), alongside the old smelting facility devastated in the mid-20th century by modern geological exploration. These beams facilitated the transportation of heavy and bulky cargo by vehicles with harnesses, preventing the road from deteriorating under the weight of use. Due to the high altitude of the site and the limited extent of the identified route, it is challenging to ascertain the specific destinations connected by this mining and metallurgical site. However, similar sites discovered within this mountainous region suggest the likelihood of a *vicus metallorum* or *villa rustica* located at lower elevations, possibly towards the modern city of Brus. The presence of Nebeske stolice, late Roman fortification in Brzeće and metallurgical centre at the spring of Minina and Srebrnačka River in the broader area of the eastern slopes of Kopaonik notably strengthens the possibility of the ancient origin of the discovered mining and metallurgical centre with the discovered road at mining and metallurgical site in Metode.

Transport to Rome

This research's specific question concerns the connection between local mining roads and the main arterial routes of Moesia Superior. All revenues from imperial domains, including all the metal produced at mines across the Empire, were sent directly to Rome in the early imperial period.²⁹ Earlier scholars questioned how all goods from the provinces were transported to the capital. As an example of long-distance transport, we have already mentioned the lead ingot of

²⁸ The first small-scale archaeological excavation was carried out at Metodje in August 2022 under the direction of the paper's first author on behalf of the Institute for the Protection of Cultural Heritage in Kraljevo, which was funded by the Ministry of Culture of the Republic of Serbia. One mining shaft, a metallurgical furnace, and a part of the road were excavated during this project. The movable archaeological material is modest and does not allow precise dating of the entire complex, pointing to two possibilities: a Roman or medieval past. Precise dating of the wooden beams will be obtained following the completion of radiocarbon (C14) analysis. This study examines the complex within the context of antiquity, given that other ancient structures are located nearby. In contrast, no medieval sites have been recorded in the vicinity. However, this does not preclude the possibility of continuous use, as evidenced by the current organisation of tourist activities.

²⁹ S. Dušanić, 1977. *op. cit.* 167-172; Idem, *Antičko rudarstvo*, u: I. Ogorelec (ur.), *Rudarstvo Jugoslavije*, Zagreb 1982: Privredni vjesnik, Savez inženjera i tehničara rudarske, geološke i metalurške struke Jugoslavije, Komitet XI svjetskog rudarskog kongresa, 121.

Kosmaj origin found in the Tiber, which arrived via a maritime route. M. Tomović, with meticulous attention to detail, examined the possible routes originating from the Kosmaj *metalla*, considering geographical settings and the network of main roads, and proposed a hypothesis involving two transport possibilities. The first pertains to a land-water route originating from Kosmaj, descending into the Ibar Valley in the region of the *Metalla Dardaniae*, where it connects to the major road Naissus-Ulpiana-Lissos, and subsequently continues by waterway to Ostia. This route would, in that case, also be logical for the transport of metals from the Kopaonik mining region, specifically for the Ibar and Janjevo domains, which gravitate towards this roadway. The possibility of using the Danube as a waterway leading to the Black Sea and further to the Mediterranean, ultimately reaching Ostia, is attributed to the transport originating from the mines in the Timok, Pek, and Mlava valleys, as well as from the domains of the *civitas Moesorum*.³⁰ Dušanić, however, argues that this route is also suitable for transporting goods from Kosmaj.³¹ An alternative possibility for transporting metal from Kosmaj is proposed by A. Škegro, who administratively linked this area with the mining district of Domavia and the Pannonian-Dalmatian mining regions.³² In that case, the proposed transport route went through Dalmatia to the provincial centre in Salona and then by sea to Rome.³³ Although all the proposed routes are existing and feasible, the question arises regarding the arguments for their selection. The route choice for transporting goods was not determined solely by the physical distance. However, it was influenced mainly by the cost of transport, which depended on various factors: the type of route (terrestrial, fluvial or maritime), transportation time, the type of goods, the condition of the road infrastructure, labour and transportation means, potential risks (e.g., *latrones*), local taxes, and others. Thus, the route choice was an economic, temporal, and logistical calculation by the imperial authorities or individuals. Over time, specific routes became established as the main or most frequent communication pathways.

Discussions about possible routes in earlier literature became the primary material for empirical verification with the development of Geographic Information Systems (GIS) and the opening of opportunities for simulating time and space. To illustrate the transportation costs on the previously proposed routes, we conducted modelling of routes, costs, and speeds with seasonal variation (summer) from

³⁰ M. Томовић, *Римско рударство и металургија сребра у Горњој Мезији*, у: Радионице и ковнице сребра, И. Поповић, Т. Цвјетићанин и Б. Борић-Брешковић (ур.), Београд 1995: Народни музеј, 126;

³¹ S. Dušanić, 2000. *op. cit.* 362, fn. 110.

³² A. Škegro, *Gospodarstvo rimske provincije Dalmacije*, Zagreb 1999, 90-91; this assumption has been questioned in many works before, see М. Величковић, *Прилог проучавању римског рударског басена на Космају*, Зборник Народног музеја – Београд I, Београд 1958, 98-103; S. Dušanić, *Le Nord-Ouest de la Mésie Supérieure*, in: M. Mirković and S. Dušanić (eds.), *IMS I*, Belgrade 1976, 95-162; B. Bartel, *Acculturation and ethnicity in Roman Moesia Superior*, in: T.C. Champion (ed.), *Centre and Periphery. Comparative Studies in Archaeology*, Routledge, London and New York 1995, 9-61; М. Томовић, 1995. *op. cit.* 117-118; Борић Брешковић, Б. и Црнобрња, А. *op. cit.* 17.

³³ A. Škegro, *op. cit.* 74.

the mining areas of *metalla Tricornensia* (Singidunum)³⁴ and *metalla Dardaniae* (Ulpiana)³⁵ to Rome or Ostia. For these analyses, we used the open-access online platform developed within the framework of the *Orbis project: The Stanford Geospatial Network Model of the Roman World*.³⁶ This open-access platform allowed us to gain insights into the impact of physical geography on mobility and the economy in the ancient period. The interactive map includes the main ancient terrestrial, fluvial and maritime routes and other forms of communication. The model considers seasonal specifics related to winds, tides, and weather conditions. We chose summer as the time frame for transport, as mining activities were primarily limited to this time of year, representing a seasonal occupation. Additionally, considering we are examining the transport of goods, we selected parameters involving cart movement (wagon and oxcart). The mathematical simulation of movement, incorporating all the mentioned parameters, yielded the following results:

The journey from Singidunum to Ostia/Portus in July

The Cheapest journey (fig. 6 – green route) takes **47.7 days** and covers **4374km**. The price in *denarii*³⁷ per kilogram³⁸ is **7.97**.

The route travelled by land: Singidunum – Taliata – Drobeta – Bononia – Oescus – Novae – Durostorum – Troesmis – Salsovia – Histria and then by sea: Histria – Mouth of Pontus – Constantinopolis – Perinthus – Parium – Kallipolis – Lampsacus – Sestus – Sigeion – Tenedos – Ephesus – Delos – Isthmisa – Skyllaion Pr. – Malea Pr. – Tainaron Pr. – Akitas Pr. – Alpheos – Ichthys Pr. – Heracleum Pr. – Regium – Messana – Palinurus Pr. – Misenum – Ostia.

³⁴ The closest place from which transportation to Rome could have started is Roman Singidunum (modern-day Belgrade), with its Danube river port and an urban ager that probably surrounded the mining area of *Metalla Tricornensia*. Between the mines on Kosmaj and Singidunum, there was at least one additional control point where the cargo was marked and prepared for transport. However, we cannot include these parameters in the research as the ORBIS platform does not integrate data on other sites in this area.

³⁵ The administration of the entire *metalla Dardaniae* was located in Ulpiana (present-day Gračanica), which was, among other things, an important station on the route from Naissus to Lissus. From there, the transport to Rome commenced after being delivered to the Sočanica, at the foot of the Kopaonik mines.

³⁶ The platform was created in 2012 as part of the *Orbis Project: The Stanford Geospatial Network Model of the Roman World*. It was developed by a team of researchers from Stanford University (Spatial and Textual Analysis - CESTA) under the leadership of Walter Scheidel, a professor of classical studies, in collaboration with experts in digital humanities (<https://orbis.stanford.edu/> accessed on December 15, 2024).

³⁷ Prices in *denarii* are based on predefined parameters involving a faster sail ship and a civilian river boat (where applicable).

³⁸ The model calculates the cost per kilogram of wheat (by wagon) as a predefined option and does not allow the selection of the type of cargo, such as ore or metal, to be set as a parameter. Therefore, the price for this type of transport should certainly be adjusted, but this does not affect the illustrative nature of the relationship between cost and travel time. All results would be proportionally scaled according to the difference in price by type of transport, with the higher cost for metal transport.

The Fastest journey (fig. 6 – red route) takes **48.2 days** and covers **1979km**. The price in *denarii* per kilogram is **15.14**.

The route travelled by land: Singidunum – Sirmium – (Domavium) – Naronia and then by sea: Naronia – Apollonia – Hydruntum – Sallentinum Pr. – Lacinium Pr. – Lokroi Epizephyrioi – Heracleum Pr. – Regium – Messana – Palinurus Pr. – Misenum – Ostia.

The shortest journey (fig. 6 – purple route) takes **62.5 days** and covers **940km**. The price in *denarii* per kilogram is **24.45**.

The route travelled by land: Singidunum – Sirmium – Cibale – Servitium – Salona and then by sea: Salona – Aternum and by land again: Aternum – Interpromium – Corfinium – Alba Fucens – Tibur – Roma – Ostia.

The journey from Ulpiana to Ostia/Portus in July

The fastest and cheapest journey (fig. 7 – red route) takes **25.8 days** and covers **1501km**. The price in *denarii* per kilogram is **7.53**.

The route travelled by land: Ulpiana – Lissus and further by sea: Lissus – Dyrrachium – Apollonia – Hydruntum – Sallentinum Pr. – Lacinium Pr. – Lokroi Epizephyrioi – Heracleum Pr. – Regium – Messana – Palinurus Pr. – Misenum – Ostia.

The Shortest journey (fig. 7 – purple route) takes **69.2 days** and covers **986km**. The price in *denarii* per kilogram is **28.71**

The route travelled by land: Ulpiana – Lissus – Dyrrachium and then by sea: Dyrrachium – Brundisium and then again by land: Brundisium – Barium – Canusium – Herdoniae – Aequeum Tuticum – Beneventum – Teanum – Casinum – Fregellanum – Ferentinum – Roma – Ostia.



Fig. 6. The possible transport routes from Singidunum to Ostia/Portus

Сл. 6. Могуће транспортне руте од Сингидунума до Остије (Портус)



Fig. 7. The possible transport routes from Ulpiana to Ostia/Portus

Сл. 7. Могуће транспортне руте од Улпијане до Остије (Портус)

The analysis showed that the mathematical model simulated the movement along the routes known from written sources, which researchers had previously identified. The additional value of the results lies in the precise calculation of the travel time along a specific route, expressed in days, and the distance in kilometres. The transport cost, expressed in *denarii*, was left as an illustration (since it refers to the transport of wheat) to highlight the relationship between the estimated value and the types and lengths of the routes. All these routes could have been in use, but the imperial authorities likely chose the cheapest route for the successive transport of ore/metals from the mining domains to Rome. For the Kosmaj metal, this route led to Singidunum, from where it went down the Danube to the Black and Mediterranean seas and further to Ostia, as proposed by Dušanić. On the other hand, the ore/metal from the mines in the Dardanian domain was transported to Rome via the land route Naissus – Lissus, the fastest and cheapest route to the Adriatic Sea, and then by sea to Ostia. We have also proven that this route, mentioned in earlier literature,³⁹ is an unquestionable transport corridor for goods, according to our analysis.

Conclusion

The preceding text provides an overview of general knowledge regarding the Roman mining roads network and data from recent field surveys conducted in two Roman imperial domains in the Central Balkans, previously unrecorded in the literature. The local roadways at all three sites in the Moesia Superior are tentatively ascribed to the Roman period based on their spatial alignment with other ancient sites within the mining domain. However, direct evidence supporting this attribution is still lacking. One contributing factor is the subsequent utilisation of these roads during the medieval period and the construction of modern roads, which often followed the paths of the original Roman routes. This pattern also extends to mining routes, as mining activities persisted into later historical periods. Consequently, there is scant evidence of medieval mining in Kosmaj, simplifying dating efforts. In contrast, the continuity of mining in Kopaonik can be traced until the early 20th century, posing challenges for research endeavours. The frequent destruction of ancient local roads, possibly caused by the substrate's instability, which has made it unable to endure sustained use for centuries, has likely resulted in the absence of evidence. Local roads, including mining routes, were often not constructed according to the standardised engineering principles used to build higher-order roads. Imperial authorities constructed higher-order roads to ensure their durability and ability to withstand frequent traffic. Even these roads exhibit variations in construction, depending on the region, the stability of the substrate, and the availability of natural materials required for building.⁴⁰ Conversely, many local roads were routed by following the natural terrain configuration, with minimal construction interventions at critical sections to ensure sufficient hardness and

³⁹ See Petrović, V. P. Some Considerations about the Roman Road Network in Central Balkan Provinces, *Roman Roads New Evidence - New Perspectives*, editor Anne Kolb, (Berlin/Munich/Boston 2019), 252–271.

⁴⁰ В. Петровић, 2007. *op. cit.* 25-26.

width of the road. In mining areas, the roads used to transport ore from the mines to the central settlement were actively utilised from the opening of the mines until the cessation of exploitation. Their quality could also vary depending on the entity commissioning the construction. If we return to Kosmaj, the road connecting the fort and the nearby mines might have been partially laid out during the construction of the castellum in the early 2nd century. Compared with Kosmaj, the examples of Kopaonik roads are different, just as the mining landscapes of these mountains vary. Thus, the mining road discovered at the Metode site is linked to a minor mining and metallurgical complex compared to the extensive works at Suvo Rudište, which are associated with the settlement in Sočanica on the west slopes of the mountain. All known archaeological structures on the eastern slopes of Kopaonik are related to the Late Antiquity, which changed the administrative organisation of mining domains. The Constitution of 386 regulated the right of magistrates from nearby cities to lease mining shafts and financially support the construction of public buildings,⁴¹ which would also include the construction of local roads. The material manifestation of these changes in Late Antiquity is recognised in the appearance of *villae rusticae* within the *territoriae metallori*, which, along with the construction of fortifications, completely transformed the mining landscape known from the earlier period.⁴² In this legally established possibility of leasing mining shafts, alongside various commercial activities, the construction of *viae metallicae* from the leased mines to settlements or the lessee's villa can be expected. This intertwining of the political power of the provincial elite with private interests opened up the possibility of increasing private capital through imperial policy. Although we cannot assert that the road discovered at Metode was built within such or a similar scenario, the size of the mine itself, the arrangement of shafts, and the quantity of slag suggest significantly more modest works than other examples mentioned in this study. The continuation of the research is expected to produce new arguments for a comprehensive interpretation of the site, which will necessarily include further tracing of the discovered road with sondage checks on specific sections.

Studies focusing on mining roads and the outer branches of road networks often encounter limitations in the archaeological evidence for their chronological determination. Thus, we preliminarily define our examples as ancient based on indirect indicators by studying ancient mining landscapes. The continuation of field research depends on funding, which often causes delays of several decades before the next phase begins. However, the advancement of information technologies, particularly GIS, allows us to mathematically simulate space and perform calculations based on data from historical sources and field research results. Digital analy-

⁴¹ S. Dušanić, 1977b. *op. cit.* 90; Idem, *Ковање новца у рудничким дистриктима римског Илирика*, Радионице и ковнице сребра, И. Поповић, Т. Цвјетићанин и Б. Борић-Брешковић (ур.), Београд 1995: Народни музеј, 223-224; A. Škegro, *op. cit.* 87; M. Марић, 2014. *op. cit.* 50-51.

⁴² The settlement model of mining domains in late antiquity in the Central Balkans is presented in M. Марић, 2014. *op. cit.*; while the case study of the western slopes of Kopaonik is discussed in M. Марић, *Late Roman Fortifications of the Eastern Part of the Metalla Dardanica Imperial Domain*. Fortifications, defence systems, structures and features in the past, *ZIA Vol.13*. 75-89.

sis of metal transport from Upper Moesia to Rome has shown that all previously assumed routes were based on written sources and earlier researchers' understanding of geographical relations. Additionally, we now know the ancient cost relations of long-distance transport, as well as travel time and exact distances, which opens up possibilities for further economic analyses. Although the layout of major roads is known from ancient authors, the emergence of LIDAR technology has allowed us to identify them in space precisely. Unlike traditional archaeological methods, this kind of desk study saves time and funds when documenting ancient pathways in the landscape. Therefore, the accurate identification of known roads and the subsequent addition of information on local roads contribute to improving our knowledge and comprehension of the Roman road system.

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РИМСКИ РУДАРСКИ ПУТЕВИ НА ЦЕНТРАЛНОМ БАЛКАНУ: СТУДИЈЕ СЛУЧАЈА ПЛАНИНА КОСМАЈ И КОПАОНИК

Територија Централног Балкана запоседнута је од стране Римљана у 1. веку наше ере. Почетак њихове владавине обележава оснивање провинција, успостављање свих нивоа власти, изградња инфраструктуре, заузимање домородачких рудника и утврђивање граница империјалних домена како би се осигурала одступница за даља освајања и организовао систем који ће доносити економску корист Царству. Основни потенцијал овог простора лежао је у рудном богатству, већ традиционално експлоатисаном од стране домородачког становништва. Запоседање рудника, формирање рудничких домена, организације административне контроле, упошљавања рудара из различитих слојева друштва, пресељавања искусних рудара из других провинција и изградња пратеће инфраструктуре био је дуг и темељно осмишљен процес спроведен у циљу ефикасне и строго контролисане организације рударства и металургије. Изградња мреже путева играла је важну улогу у организацији и функционисању рударских активности, омогућавајући транспорт сировина и производа, комуникацију између рударских центара и административних центара, као и интеграцију рударства у ширу економску мрежу римског царства.

У раду су разматрани новооткривени делови путне мреже који се могу назвати *via metallica* у оквиру *metalla Tricornensia* – област Космаја и *metalla Dardaniae* – област Коапоника у оквиру ибарског домена. Историјски извори не дају информације о рударским путевима, тако да је археолошка препознатљивост у савременом пејзажу једини извор којим располажемо. То су најперифернији делови путне мреже којима је руда допремана од рудника до металуршког центра и административног пункта где је вршено њено мерење, обележавање и припрема за даљи транспорт. У раноцарском периоду сви приходи са империјалних домена, укључујући и сав метал произведен на рудиштима широм Царства, стигао је директно у царску касу у Риму. У старијој литератури разматрана су питања путева којима је метал из централнобалканских провинција допремен до престонице. Користећи предефинисане ГИС анализе на ОРБИС платформи, потврдили смо главне трасе транспортних коридора, додатно разматрајући прецизне путање, дужине путева, трајање путовања и цене транспорта. Егзактност добијених резултата води ка општем, дубљем разумевању путне мреже и транспорта у оквиру римског економског система.