

RELATIONSHIP BETWEEN THE ROMAN ROADS AXES IN TRANSYLVANIA AND MAJOR HYDROGRAPHIC AXES

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Abstract: Relief and hydrography have constituted, since the earliest times, the main axes delimiting civilization. The two natural factors, through their specific characteristics, can represent either favorable or restrictive factors in the development of human settlements. Consequently, the configuration of the relief and the presence of watercourses have influenced the choice of locations for settlements, the development and type of economic activities, while also serving as reference points for the creation and development of routes of access and communication. Moreover, these factors influenced the development of Roman roads, often built along valleys and natural corridors that facilitated the movement of flows. The Roman roads of Antiquity represent one of the models applied by the Romans, demonstrating that hydrography played a very important role in their creation. Thus, in the territory of Transylvania we have two major axes: the Someș and the Mureș. Based on the course of these waters and on all the factors involved in hydrography, the Roman roads and their settlements were concentrated around these two major axes and their tributaries. The result of this research was the delineation of the axes of the Roman roads, which are closely linked to the natural relief and the hydrographic network. The axes received a measurable and quantifiable identity: The Defensive Axis of Dacia Porolissensis based on the natural course of Someș tributaries, The Someș Limes Axis – a defensive axis on the northern frontier of Dacia Porolissensis, The Someș Limes Axis – a Defensive Axis on the Northern Frontier of Dacia Porolissensis, The Mureș Limes Axis – a southern Carpathian barrier. All four limes axes presented in this article have territorial connectivity and form a road system which, although initially built for military and administration, today represents an important point of economic development, preserving its connectivity function up to the present day.

Keywords: axes, hydrography, Limes, roman road, river valleys, territorial organization, Transylvania

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INTRODUCTION

The earliest information regarding the waters of Romania and their hydrological regime dates back to ancient times, when the inhabitants of these lands began to use them for various practical and economic purposes. Evidence indicates that as early as the Geto-Dacian period, the waters of the Danube were used for navigation, while the remains of military fortifications discovered along the river demonstrate that these sites also functioned as ports. Archaeological excavations have revealed clay water pipes dating from the period of Roman ruling in Dacia (Ujvári, 1972).

Romania's geographical position within the temperate continental climate zone, and the presence of the Carpathian arc at its center of the country, strongly influence the hydrographic network. Rivers constitute the most important category of water resources. They are closely linked to the Carpathian and Subcarpathian mountain regions, as this is where most rivers originate and where the main characteristics of liquid runoff are defined.

While the Carpathian arc gives the hydrographic network a radial-divergent configuration, the Danube acts as the collector of approximately 97.8% of the country's surface area. These characteristics allow Romania's rivers to be considered Carpathian in origin and Danubian–Pontic in terms of drainage. The total length of watercourses recorded in Romania's water cadastre is 66,029 km, with a total number of 4,295 rivers.

A major axis dominating the central part of Transylvania is the Mureș River. Its axis crosses the depression from south to north over a length of 71.5 km and includes 55 tributaries. The longest tributaries originate near mountain passes along the surrounding mountain frame, such as the Toplița River near the Mesteacăn (or Creangă) Pass, and the Jolotca and Ditrău rivers near the Ditrău Pass (Pop, 2016). The Mureș River rises in the Eastern Carpathians, in the Hășmașul Mare Mountains, at an altitude of approximately 850 m. The Mureș hydrographic basin covers a total area of 29,289 km², of which 28,310 km² lie on Romanian territory (including the Ier Canal), representing 11.7% of the country's total surface area. The river flows largely on Romanian territory, covering 761 km of its total length of 766 km, with only a short section flowing through Hungary. The cadastral hydrographic network within the Mureș basin

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comprises 758 watercourses with a total length of approximately 10,800 km. The Mureș hydrographic basin encompasses all major relief forms. The landscape displays considerable diversity, ranging from plains to mountains. The minimum altitude is approximately 80 m at the point where the river exits the country into the Western Plain, while the maximum altitude reaches 2,509 m in the Retezat Mountains.

Approximately 25% of the basin area is mountainous, 55% consists of hills and plateaus, 15% comprises valleys and floodplains, and 5% is made up of plains. Figure 1 presents the hydrographic basin of the Mureș River.

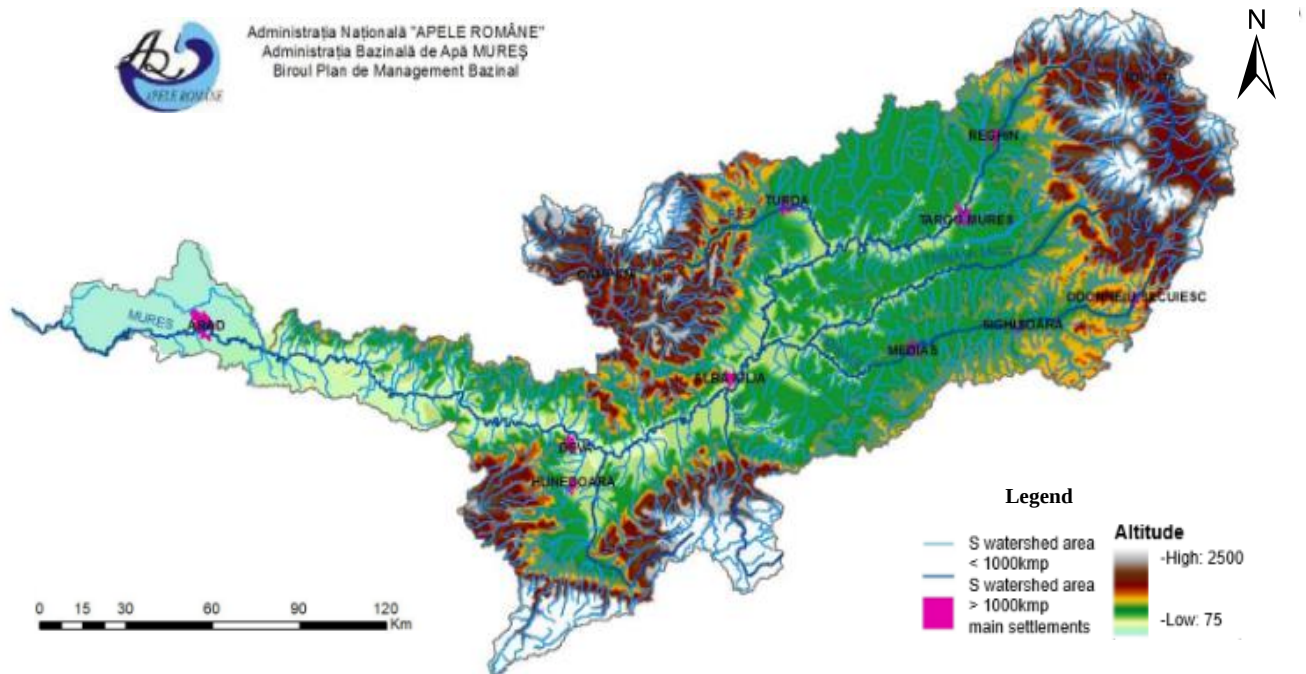


Figure 1. The main landforms in the Mureș River basin

Located in the west-central part of the country, the Arieș River flows through an area rich in natural resources and picturesque landscapes, while also benefiting from a climate favorable to the development of human communities.

The hydrographic basin from which the river collects its waters covers an area of 2,970 km², making it one of the medium-sized rivers in the country. Along its west-to-east axis, the Arieș crosses all three landform types, passing successively through mountainous, hilly, and then plain terrain.

The Arieș hydrographic basin belongs mainly to Alba County to the southwest and Cluj County to the northeast, with a smaller share in Arad, Bihor, and Hunedoara counties to the west and in Mureș County to the east (Dîscă, 2022).

The Mureș Corridor has represented an important communication zone throughout all historical periods. The Mureș Corridor is defined by several essential characteristics. First, the elevation difference between the corridor and the two neighboring geographical units is approximately 150 m. Second, the course of the Mureș River (with the exception of the area near Târgu Mureș) developed extremely close to the southern boundary of the Transylvanian Plain, forming a cuesta zone that is still visible today in many places. As a result, areas suitable for settlement developed primarily on the left side of the corridor, where the floodplain is well developed, reaching a width of approximately 3 km.

These important hydrographic characteristics have led, over time, to the valorization of this geographical potential, as reflected by the high density of settlements during various historical periods, including the Roman era (Fodorean, 2004). A second major hydrographic axis is the Someș Valley axis. The Someș hydrographic area is located in the northern and northwestern part of Romania, bordered to the north by the Tisza River basin—partially located in Ukraine—to the west by the border with Hungary, and within the country by the Siret Basin to the east, the Mureș Basin to the south, and the Crișuri Basin to the southwest. From an administrative perspective, the Someș hydrographic area covers the territory of seven counties: Cluj, Sălaj, Bistrița-Năsăud, Maramureș, Satu Mare, Alba, and Bihor.

The contribution of the latter two is insignificant. The degree of industrialization of the hydrographic basin's territory is relatively high, reflected in numerous economic branches, of which the following activities hold the greatest weight: ore extraction and processing, machine building, metallurgy, the construction materials industry, the chemical industry, the textile industry, the food industry, and timber exploitation and processing (Sofronie, 2000)

The name of the Someș River originates from the Dacian word Samus. It belongs to a group of geographical names dating from the Dacian period, which also includes Alutus (Olt), Crisus (Criș), Istros (Danube), Maris (Mureș), and Tyras (Dniester). Approximately 150–160 basic words from the Dacian language have been preserved, primarily in the form of toponyms and hydronyms. Within this geographical framework, the valleys of the Mureș and Someș rivers functioned as natural axes that facilitated the development of Roman roads and settlements. The positioning of forts and communication routes within the Roman province of Dacia was closely related to these hydrographic corridors, which offered both strategic advantages and access to natural resources. Figure 2 presents the hydrographic basin of the Someș River.



Figure 2. Someș River Basin

There was a fairly extensive system of Roman roads in Transylvania, and the location of these roads is directly related to natural factors, their permissibility and utility. The Roman roads in the Bărgăului Mountains are directly influenced by the accessibility of valleys and natural corridors, being linked to existing hydrographic networks (Băca, 2012).

Main watercourses, or hydrographic axes, have represented early areas of population concentration, while their characteristics have provided favorable conditions for development. As areas of long-standing settlement, they benefit from significant archaeological potential. For example, the ISTER project focuses on promoting the cultural potential of the Danube region. The project aims to promote Roman roads as coherent transnational elements, an approach considered useful and beneficial for sustainable territorial development (ISTER, 2022). The potential and usefulness of such an approach is also argued by other studies (Jovanović et al., 2022; Amato et al., 2026).

River valleys play a crucial role in the location of tourist centres, representing a linear-nodal territorial structure of tourism (Dunets et al., 2024). The aim of this article is to analyze the relationship between the axes of Roman roads in Transylvania and the major hydrographic corridors represented by the Mureș and Someș rivers. Cultural heritage and archaeological legacy exist along the course of these rivers, therefore it must be highlighted. These historical routes create a tourism potential for the development of this sector and it shapes territorial connectivity for future development of archaeotourism and cultural tourism in region of Transylvania. One of the major objective of this research is to interpret the natural corridors given by hydrographic axes and archaeological heritage as a potential relevance in tourism.

MATERIALS AND METHODS

The study of geographical axes in the specialized literature has attracted the interest of many researchers and has led to much more concrete knowledge in this field. The theory of the geographical axis can be found in several studies that focus on the economic, geographical, and social image of Europe. Laitin, Moortgat & Robinson (2012) test the continental axis theory advanced by Diamond (1997), according to which east–west expansion facilitates the diffusion of agricultural innovations, technologies, and cultural homogenization, whereas north–south expansion preserves cultural diversity due to greater climatic and ecological variation. In addition to providing empirical support for these hypotheses, the authors also examine the economic trends and the geographical and historical implications shaping cultural identity. The main historical implication of this research is that continental axes, understood as geographical factors, have played a crucial role in shaping history and continue to influence contemporary cultural diversity, which in turn generates significant social, economic, and political consequences. The present research is based on a geographical and geo-archaeological approach that analyzes the relationship between Roman road networks and the major hydrographic corridors of Transylvania. The study focuses on identifying the spatial relationship between Roman roads, military forts, and the natural hydrographic framework represented mainly by the valleys of the Mureș and Someș rivers.

Various categories of data from all the fields addressed were used. Among them are data on history and archaeology, geographical and cartographic data to which are added data on tourism in the study area but also relevant information on the current transport infrastructure as well as that of antiquity. The current research involved the use of quantitative and qualitative methods, all scientifically validated to determine the geographical, archaeological and tourist approaches.

The concept of geographical axes has been studied over time from the perspective of territorial organization, transport networks, and the influence of natural factors on the development of human settlements. Iurea & Brăghină (2012) describe development axes as corridors of concentration and diffusion of population, goods, capital, and information flows generated by development poles, mainly along major communication routes. These axes support the urban-rural relationship by facilitating the spatial diffusion of development from urban centers to nearby rural settlements, and underpin polycentric networks capable of attracting investment and reducing disparities between developed and peripheral areas. Given their recognized role in spatial development policy, integrating this perspective

into the valorization of the axes proposed in this study becomes necessary. These concepts were later adapted to the study of historical road networks, especially Roman roads, due to their importance in structuring the territory of Dacia.

The development of historical roads is closely linked to geographical axes, which are often determined by natural features, trade routes, political boundaries, and cultural connections. Geographical axes—such as mountain chains, rivers, valleys, and coastlines—have historically influenced the direction and layout of roads.

Geographical axes refer to natural or human-defined lines that guide movement and connectivity. These axes have often determined the alignment of historical roads through natural features:

- rivers served as natural axes for transport and trade, and roads often developed along river courses to facilitate movement and access to water.

Campbell (2012) addresses the main themes that made river courses strategic and economic elements in the development of Roman roads. The most suitable examples of hydrographic axes were the Danube, Rhine, Nile, and Tiber, which were used as trade routes, functioning as “natural highways” facilitating the circulation of goods and people. Roman settlements were designed, located, and aligned along river axes to ensure high connectivity and access to resources.

Horden & Purcell (2000) argue that rivers were essential resources and transport routes, and many types of settlements shaped their economic activities along them. Rivers were interpreted as geographical axes because they acted as linking poles, being vital axes for trade that connected areas and territories.

Whittaker (1994) succinctly presents how geographical-type axes influence the development of Roman frontiers. In this case, attention is focused on hydrographic axes, which had a military and defensive purpose, as well as a strategic role in connectivity and facilitating the circulation of goods throughout the empire. Remaining within the same framework, Wilson (2019) explains how rivers played a crucial role in the economy of the Roman Empire and fulfilled their role as “natural highways” and economic axes. The Romans invested heavily in water-related infrastructure, including the construction of bridges, canals, ports, and storage facilities. The author’s article addresses the relationship between hydrographic axes and Roman roads, as Roman roads were built along rivers to connect settlements and facilitate trade.

The information taken in this research comes from the study of specialized literature found in scientific articles in national and international journals of specific interest, current publications but also from the last century in the field of geography and history and numerous monographic research.

Based on the previous information, the elements that characterize the study area were identified. The spatial framework in which I place the research was analyzed based on current geographical information and outdated research that still presented nuances of topicality. The historical data research was based on both ancient historical sources and the results of modern archaeology. Also within these sources, we placed cartographic and geospatial data thanks to the maps taken. The tourism infrastructure was analysed through digital sources provided by the National Institute of Statistics and validated through field study. The method of observation and field research involved the analysis of the accessibility and current state of conservation of archaeological sites. The quantitative method supports and validates scientific knowledge and allows for the analysis of the identified phenomena with high accuracy.

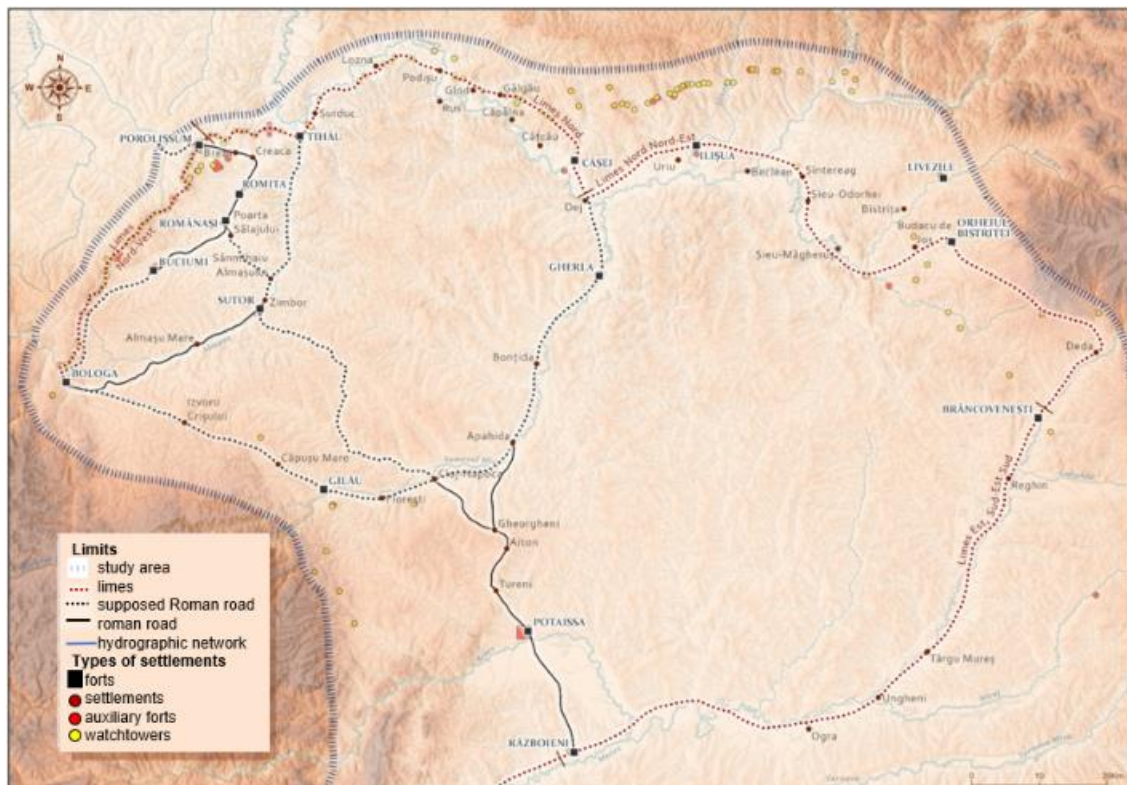


Figure 3. The northern limes route of Dacia Porolissensis (Source: Authors)

RESULTS AND DISCUSSION

These axes are the result of an accumulation of archaeological sites generated by the construction of Roman military structures, closely linked to the natural relief, hydrographic networks, and strategic positioning within the territory.

The placement of the forts was conditioned by factors such as visual dominance over the landscape, control of waterways, and proximity to circulation corridors and administrative centers. Figure 3 presents the location of the northern limes of Dacia Porolissensis.

Thus, the proposed axes function as territorial organisms with economic, social, and residential roles.

The tracing and delimitation of these axes pursue several objectives: the reconstruction of the Roman military structure, the highlighting of the tourism and spatial valorization potential of the heritage, and the demonstration of the current relevance of Roman roads and settlements. Starting with the network of forts on the northern Limes and continuing with those inside the Roman province, located along the main imperial roads, geo-archaeo-touristic axes with their own geomorphological specificity are proposed.

Within this chapter, the following geo-archaeo-touristic axes are proposed: the defensive axis of the western forts of Dacia Porolissensis; the Someș Limes axis, a defensive axis on the northern frontier of Dacia Porolissensis; the intra-Carpathian Limes axis from the Meseș Mountains to the barrier of the Eastern Carpathians; and the urban-imperial axis Potaissa – Napoca – Porolissum. Based on these axes, initiatives can be substantiated to integrate historical research into a modern tourism framework, in line with current trends in regional and cultural development at the European level.

The Defensive Axis of Dacia Porolissensis based on natural course of Someș tributaries

The mountainous area of Sălaj County is located in the southern part of the county, comprising two major ridges: the Meseș and Plopiș ridges (600-900 m). The hilly area—the largest in extent—belongs to a highly complex unit known as the Someș Plateau; the most significant part is the Sălaj Plateau, which is bordered by the Meseș ridge to the east, the Plopiș Mountains to the south, the Baia Mare Depression to the north, and the Western Plain.

This landform unit has an average elevation of 150-300 m, consisting of gentle hills, mostly deforested and cultivated, and is crossed by the wide valleys of the Barcău, Crasna, and Sălaj rivers. In the eastern part of Sălaj County lies the Almaș Depression, drained by the Almaș Valley, and the Gârbou Depression, located along the Someș Valley.

The three main plains in Sălaj County are the Someș, Crasna, and Barcău Plains. They are small in extent and appear as elongated strips along the riverbanks, formed from alluvial deposits. The hydrographic network of Sălaj County is evenly distributed, with a high density (0.7-0.9 km/km²). The Someș River crosses the county for approximately 70 km, with its main tributaries being the Almaș and Crasna rivers. Other rivers in the county, such as Agrij, Barcău, Sălaj, and Valea Zalăului, are of local importance, with higher flow rates only during snowmelt and heavy rainfall.

The delimitation of this axis begins with the fort at Bologa and ends at the military complex of Porolissum. The natural framework to which this axis belongs has a coherent morphological and functional impact. This corridor within the Limes of Dacia Porolissensis capitalized on mountainous relief, largely formed by the Meseș Mountains, and on a hydrographic network based on the courses of the Almaș and Agrij valleys. The Agrij River rises in the Apuseni Mountains, in the Meseș Mountains area, where it gathers all its tributaries. It flows northward, discharging into the Someșul Mare at Jibou, running parallel to the Meseș Mountains. The chain of hills east of the Agrij separates its valley from the Almaș Valley, which flows parallel to the Agrij and empties into the same area near Jibou. These two valleys thus form two corridors that penetrate deep into the province of Dacia (Matei & Bajusz, 1997).

Almaș and Agrij are secondary rivers, but they have proven to be vital within the segments of this axis. This sector of the Limes also represents a natural barrier between the Transylvanian Plateau and the Tisza Plain, once again demonstrating the appropriate choice made by the Romans in creating roads and erecting forts.^b These two axes represent two geo-archaeological corridors that integrate natural elements of relief and hydrography, as well as anthropogenic military elements such as Roman roads and forts. The scale and historical load present along these corridors represent the development potential of tourist circulation flows.

The Someș Limes Axis – a Defensive Axis on the Northern Frontier of Dacia Porolissensis

The geographical positioning of this defensive axis is set within the natural framework of the Transylvanian Depression, a terrain that has favored, since Antiquity, the development of military roads and Roman forts. The northern limes of Dacia Porolissensis surrounds the geographical core of this depression with a well-branched hydrographic network, especially centered on the main river, the Someș. The river crosses the proposed axis from west to east, longitudinally, creating a corridor that links the Transylvanian Depression with the mountainous area of the Carpathians. The Someș Limes axis includes the Roman roads that connect the forts: Porolissum – Tihău – Cășeu – Ilișua – Orheiul Bistriței.

The Roman forts within this geographical space are closely connected to the main hydrographic axis. The fort at Tihău is located at the contact between the Meseș Mountains and the western extremity of the Someș corridor; the fort at Cășeu is placed on a high terrace of the Someș; the fort at Ilișua lies on the floodplain of the Someș; and the fort at Orheiul Bistriței is positioned in the area where the route exits the intra-Carpathian space toward the Bistrița corridor.

The Transylvanian Depression area was identified by the Romans and later validated by specialized literature as a space of balance and convergence. The Someș Limes axis can acquire significant tourist value, as it fits into a landscape that still preserves traces of Roman presence from Antiquity. This network of fortifications is not accidental, but rather the result of a coherent strategy for managing the northern frontier. The Someș corridor, oriented west–east, functioned as a natural corridor for transport and migration, but also as a potential invasion route. Its control was a military necessity for the Romans.

The Mureș Limes Axis – A southern Carpathian Barrier

The Mureș area represented an important community area in all historical periods, its corridor being defined by several essential characteristics, characteristics that favored the geographical potential it had to offer especially in the Roman area (Fodorean, 2015). The archeological excavations carried out in the county led to discovery of material and intangible evidence of human traces on the main geographical axis.

As in our days, the Mureș River valley was a great important transport and communication route in historical Transylvania. The oldest evidence of transport traces is given by Roman roads (Berecki et al., 2013). The chronological setting of the roads is difficult to identify, but at the level of the Mureș valley in Mureș County, some traces of the presence of Roman roads can be found. Figure 4 presents the location of archaeological components along the Mureș Axis, in Mureș County. The Mureșului Corridor is located at a level difference between the two neighboring geographical units of about 150 meters, making this course extremely close to the southern line of the Transylvanian Plain. This fact facilitated the more pronounced development on the left side of the corridor where the long one is better developed with approximately 3 kilometers wide (Fodorean, 2015). The geographical and hydrographic characteristics of this area led to the exploitation of a Roman traffic road since Prehistory.

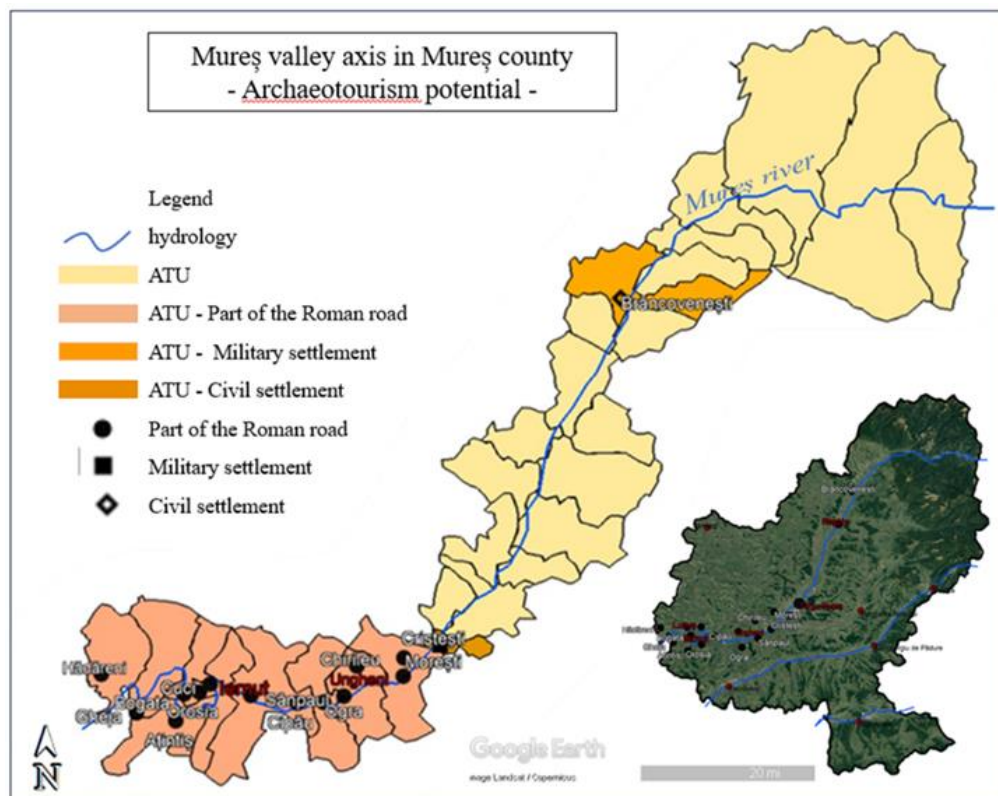


Figure 4. Villages with archaeotouristic discoveries on the Mureș Valley in Mureș County
(Source: http://www.eemj.icpm.tuiasi.ro/pdfs/vol23/no1/3_550_Gudea_23.pdf)

Beyond their historical and geographical significance, the axes identified in this research also present important potential for cultural and heritage tourism. The concentration of Roman forts, settlements, and road segments along the hydrographic corridors of the Mureș and Someș rivers creates the conditions for the development of thematic tourism routes based on Roman heritage. These geo-archaeological corridors combine natural landscapes with archaeological remains, offering opportunities for the interpretation of historical landscapes and for the valorization of the Roman presence in Transylvania. The spatial continuity of these axes allows them to be interpreted as archaeotouristic corridors that connect several important archaeological sites. Roman forts such as Porolissum, Tihău, Cășeu, Ilișua, and other settlements located along the hydrographic valleys form a network of sites that can be integrated into cultural tourism itineraries. The presence of natural corridors, accessible valleys, and historically documented routes facilitates the creation of thematic trails that combine archaeological heritage with the natural landscape.

From a territorial perspective, the valorization of these historical axes can contribute to the development of sustainable tourism in the regions crossed by the Mureș and Someș valleys. The Roman road and the identified prehistoric remains overlap, at county level, with the Mureș Valley axis, highlighting its role as an important natural corridor for movement and territorial connectivity. The Roman road and prehistoric remains overlap with the Mureș Valley axis, highlighting its role as a natural corridor of movement and connectivity. This relationship can support archaeotourism along the Mureș Valley and contribute to the sustainable development of the territory (Gudea et al., 2024).

The integration of Roman archaeological sites into tourism circuits could support the diversification of tourism activities, promote local heritage, and strengthen the cultural identity of the region. In this context, the Roman road axes

can be interpreted not only as historical communication routes but also as elements of contemporary territorial development, contributing to the promotion of archaeotourism and cultural tourism in Transylvania.

CONCLUSION

The road network analyzed in this article represents one of the most durable and influential transport systems developed in Antiquity. In synergy with physical geography—relief and hydrography—Roman infrastructure was strategically designed to meet the military, administrative, and economic needs of the province of Dacia. Roman roads connected forts and urban centers with one another and with frontier points, being constructed with considerable technical rigour, maximum visibility, territorial control, and easy access to natural resources.

This network not only physically endured in the landscape but has also preserved its relevance and influence up to the present day, directly or indirectly shaping the routes of modern roads. Roman roads can be regarded as generators of territorial development axes. Urban settlements that formed in the vicinity of these roads experienced accelerated urbanization, many of them being elevated to the status of municipium or colony.

All limes axes presented in this article have territorial connectivity and form a road system which, although initially built for military and administration, today represents an important point of economic development, preserving its connectivity function up to the present day. The geographical axes that acquire a historical role in the case of Roman roads are reliable elements of sustainable development through the existing archaeological heritage.

The concentration of Roman archaeological sites, including forts and settlements located along these hydrographic corridors, creates opportunities for their interpretation as geo-archaeological routes. From a tourism perspective, the integration of Roman archaeological sites located along the Mureş and Someş valleys into thematic tourism routes could contribute to the promotion of historical heritage and to the diversification of tourism activities in Transylvania. Such initiatives could strengthen the connection between archaeological research, landscape interpretation, and sustainable territorial development. In this context, the Roman road axes identified in this study represent not only elements of the historical organization of space but also potential resources for the development of cultural and heritage tourism.

Local hydrography together with the geographic factor greatly influenced the construction of the Roman roads, which leads to the conclusion that they were not an obstacle but the foundation from which the shape of the road network originated. The Mureş and Someş corridors were natural axes from the very beginning. The optimal geomorphological conditions imposed within the landscape of the hydrographic structure the Roman military infrastructure, which has been preserved to this day and has become axes with economic, infrastructural, and communication value.

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