Routeways in Sicily’s Middle Bronze Age. Remote Sensing analysis of Internal Communication Routes through the Territory of Milena

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This research attempts to locate the pathways used during the Sicilian Bronze Age in the territory of the municipality of Milena (Caltanissetta, Italy), in a central area of the island. The study begins by analyzing settlement's superimposition from the Neolithic period through the Middle Ages. Using an interdisciplinary approach, it was possible to identify and hypothesize prehistoric routeways by combining UAV technology, remote sensing, and GIS applications. Thus, studying the ancient movement areas without new material evidence of their existence is possible. This methodological approach is a solution for identifying specific prehistoric pathways across the interior of Sicily. The settlement logic of the hinterland and mountainous areas on the island can sometimes be replicated in other parts of the island. The good results obtained allow us to use this case study as an example of best practices in identifying specific prehistoric routeways through the analysis of topographic features with combined technological methods to study other similar contexts.

Keywords

Topography, GIS, Routeways, Landscape, Sicily, Bronze Age.

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1. INTRODUCTION

Various studies have sought to reconstruct the ancient pathways of Sicily, examining literary sources, scarce physical evidence, and the evolution of the landscape using GIS analysis [Muratore 2013; Rotolo 2016]. These works have primarily sought to reconstruct the Greco-Roman road systems, with a few case studies dedicated to those of the medieval period. An important example is the work carried out by Uggeri to reconstruct the roads of the Roman period, and in so doing also indirectly reconstruct the Greek road system upon which later roads were built [Uggeri 2004]. However, studying natural landscapes used in prehistory has often taken a secondary role. As this study shows, the Roman roads, just like their medieval counterparts, tended to reuse routes used since the end of the Early and Middle Bronze Ages.

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Research carried out by Giannitrapani in central Sicily, for example, has already highlighted the relationship between humans and the environment during these earlier periods, analyzing the level of interaction between settlement systems and movement through space [Giannitrapani 2017; Giannitrapani 2021]. Other works have studied how the characteristics of peculiar environments, such as the volcanic region around Etna, clearly conditioned settlement choices in the area [Branca et al. 2021]. Studying these characteristics makes it possible to understand the settlement logic of the communities that lived within Sicily during prehistory. These patterns in many cases overlap those of the peoples of successive periods, as has been observed in southeastern Sicily. For example, at Cozzo del Pantano, research carried out by Tanasi has shown the presence of Greek routes in proximity to areas occupied continuously at least since the Middle Bronze Age [Tanasi 2023]. In this case, how the same areas were reused over centuries was analyzed, considering a given route as one of the principal reference points. Based on these observations, routes have become a potential common thread able to unite very different communities through time.

Studies with different approaches concentrate on the topographic relationships between settlements and the landscape to reconstruct pathways in historic periods starting from an analysis of particular geomorphological landscapes, such as rocky areas [Cugno 2016; Cugno 2020]. In the same vein, the work carried out by Brancato on the plain of Catania studied the relationship between settlement systems and the route network from prehistory to the medieval period [Brancato 2020]. Beginning with the identification of sites that saw continuous occupation over the centuries or had successive periods of habitation, the author was able to analyze and observe an evolution in the way the landscape was settled in the *longue durée*.

However, that which seems to be missing from the last decade of research on the topography of ancient Sicily is a study focused exclusively on, the pathways of the prehistoric period and its impact on the natural and anthropic landscape. This includes how indigenous communities chose to move and transport goods within the landscape. To better understand why the topic has never been adequately covered until now, it is necessary to consider, on the one hand, the ephemeral material evidence of prehistoric movement structures virtually invisible without remote sensing analysis, and on the other hand, the lack of an appropriate case study with the necessary evidence to demonstrate its feasibility.

This contribution uses the territory of Milena (Caltanissetta) as a case study for the combined application of innovative remote sensing techniques. It will shed light on hitherto unknown aspects of the pathways used in prehistoric Sicily and offer ideas on how to export this “Milena-model” to other contexts on the island.

2. THE CASE STUDY OF MILENA

2.1 Geomorphological context

The area of Milena is rich in water, thanks to rivers and many natural springs[1] [Fig. 1]. The location of most of the prehistoric settlements in the area corresponds to springs that are active to this day. For example, in the locality of Monte Grande, an area with numerous tombs and prehistoric settlements [La Rosa 1997, 73-78], there are three springs. In other cases, such as Rocca Aquilia, there are springs very close to settlements with signs of human habitation in the prehistoric, Roman, and medieval phases [Regione Sicilia 1999], which are still used today to fill drinking troughs for animals.

The ample presence of water in the area is guaranteed by the Platani River and its tributaries, such as the Gallo d’Oro, through the territories of Campofranco and Milena. The tributary meets the Platani river a short distance from Monte Conca, a locality with evidence of inhabitation from the Neolithic to medieval periods [La Rosa & Arcifa 1997:269-270]. From this peak’s summit it is possible to oversee the exact area where the two rivers meet, in addition to the wide valleys that extend both north and south. This evidence of inhabitation suggests that the area of the convergence of the Gallo d’Oro and the Platani rivers has always represented an important junction throughout history. The notable presence of waterways has over the millennia generated an incisive geomorphological process that formed the basin of the Gallo d’Oro to the west and north of the municipality of Milena and of the Vallone Coda di Volpe and the Platani to the east. This erosion on a geological time scale contributed to the creation of large, eroded valleys between chalky hills that dominate the valleys like those that flow into the Platani basin, or which are a part of it for all intents and purposes [Saia 1997:19-20]. The rivers, as such, have played an important role in the gradual modeling of the landscape. Through the millennia, they slowly excavated the region, creating valleys large and small, shaping, from an orographic perspective, a decidedly harsh panorama characterized by a constant succession of mountains and hills [Regione Sicilia 2015:91-92]. In the past, the flow of the rivers must have been decidedly greater. They were only fordable in a few specific locations, probably concentrated along the Gallo d’Oro River considering the breadth of the Platani River, and its crossing is still dangerous today. The only flat areas in such a stony and mountainous region are located on the valley floors of the Platani, Gallo d’Oro, and Salito rivers [Regione Sicilia 2015:92].

The presence and exploitation of rock salt and sulfur have characterized the history of the region. The economy was always dependent on mining which has employed generations of Sicilians and therefore has become, along with agriculture, the primary means of subsistence [Regione Sicilia 2015; Regione Sicilia 2022]. The first signs of activity dedicated to the extraction of sulfur and rock salt were documented in the Imperial Roman period [Salmeri 1997:263-268]. However, signs of possible extractive activities during the prehistoric period have also been identified in areas adjacent to Casteltermini (AG) [Gullì 2016:106], a town nestled within a similar geological structure a short

[1] Among the principle water sources, distributed between the municipal territories of Campofranco and Milena include: Spagnolo and Lu Capo (Serra dei Morti); Funtanazza, Menta, Mustansello (Monte Grande); Catusu, Funtana Dunci, Masaniello-Cinnirella, Trumello-Acqua Calla (Serra della Croce); Jannigallo (Serra della Croce/Monte Campanella); Pili, Macchia (Monte Campanella), Abbeveratoio Rocca Aquilia (Rocca Aquilia); and Quattro Finaite (Monte Pernice); Gifitello and Bonfiglio (in the town of Milena), Maniscalco (Monte Maniscalco/Monte Conca) [Saia 1997, 23-24].

distance from Milena. The presence of bituminous oil, springs of sulfurous water, and deposits of rock salt and sulfur are well documented in this area, as well as more generally along the Platani River valley. Some studies have highlighted how the presence of similar geological formations often lead to the development of stable settlements over time, to the point of showing signs of occupation through the medieval period [Gullì 2003:375]. The landscape is characterized by geologic features ranging from 300 to 400 meters in height, with the notable exception of the 662-meter-tall Monte Campanella. Their location is peculiar, considering that they are mainly arranged in perfect succession along the valleys from the North to the South-Southwest, thus making them ideal spots for the foundation of settlements for overseeing the territory and therefore the possible routes that crossed it.

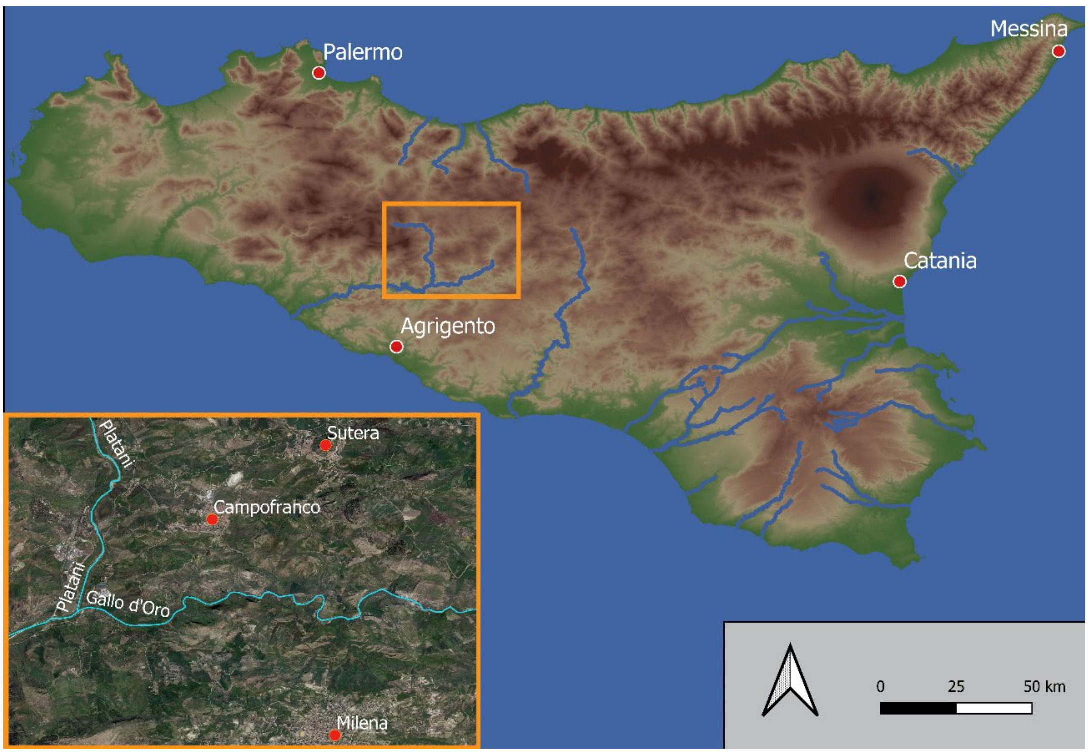

Figure 1. Map of Sicily showing the location of Milena, Campofranco, and Sutera territories around the rivers Platani and Gallo d'Oro. Colorized version of the DEM from Tinitaly DEM made available by the Sezione di Pisa Istituto Italiano di Geofisica e Vulcanologia [Tarquini et alii 2007; 2023]. Generated from Google Map data ©2015.

2.2 Prehistoric Archaeological Context

The prehistoric landscape of Milena is characterized primarily by its settlements, which in many cases present persistent signs of frequentation in the Neolithic, Bronze, and Iron Ages, but also during the Roman and medieval periods. Studies conducted in the Fontanazza 1 cave at Monte Grande demonstrate the presence of successive stratigraphic phases related to the Middle Bronze Age [Maniscalco 1997:63]. These demonstrate a constant human presence in the area throughout the Copper Age, and a reoccupation during the Early and Middle Bronze Ages.

To understand the origin of these sites, it is necessary to understand the landscape. This includes the set of geomorphological, topographic, geological, and hydrological characteristics of the area under study, and of the most significant changes it has undergone over time [Kempf 2020; Giannitrapani 2018]. All the places with signs of habitation have the same geomorphological characteristics. Typically, the settlements are near a river or stream and occupy a plateau near the top of a hill. This method of settlement favors a more efficient exploitation of the land to mostly productive ends. It also reflects the uses and customs of the Sicilian peoples present on the island since prehistory according to a pattern that is maintained by communities of successive periods [Fitzjohn 2007]. It is likely that the presence of the Platani River favored the arrival of imported material already as far back as the Middle Neolithic period from the coasts of Agrigento to its hinterland. This is evidenced by the presence of obsidian from Lipari and Pantelleria at Milena [Freund 2017:35-48; Pappalardo et al. 2013; Ceruleo 2003]. For example, the presence of obsidian in an area so far from the coast, together with a coeval presence of Diana-style pottery, confirms that the area was an active part of the trading system with people from different parts of the Mediterranean in the Neolithic period [Zilhão 2013:185-200; Calderone 2020]. This characteristic is confirmed in later periods, especially in the Bronze Age, when goods and products from the Aegean appeared in the area [Tanasi 2005].

Tab. 1: Table illustrating the local pottery production compared to the ceramic productions of Aegean type attested in the territory of Milena from the Middle Neolithic period to the Iron Age. The chronological succession of the Sicilian pottery in this table is inspired by S. Tusa 1999.

Archaeological phases	**Years [BCE]**	**Ceramic productions**	**Aegean**
Early Neolithic	6200-5700	Archaic Impressed pottery	EN
Middle Neolithic	5700-4500	Stentinello incised and impressed pottery; bi- and trichrome-painted pottery	LN I a
Late Neolithic I	4500-4000	Diana style pottery	LN I B
Final Neolithic	4000-3700	Diana-Spatarella style pottery	LN II a
Early Copper Age	3700-3300	S. Cono-Piano Notaro incised pottery	LN II b
Middle Copper Age	3300-2800	Serraferlicchio painted pottery	EBA I
Late Copper Age	2800-2350	Malpasso style pottery	EBA II
Final Copper Age	2350-2150	S. Ippolito painted pottery	EBA III
Early Bronze Age	2150-1800	Castelluccio painted pottery	EBA III-MBA I
Middle Bronze Age I-II	1800-1450	Castelluccio painted pottery; Rodì-Tindari-Vallelunga style pottery	MBA II-LBA I-II
Middle Bronze Age III	1450-1270	Thapsos style pottery	LBA III A-B1
Late Bronze Age	1270-1150	Pantalica style pottery	LBA III B2
Final Bronze Age	1150-1050	Cassibile style pottery	LBA III C / Submicenean
Iron Age 1	X-IX sec.	S. Angelo Muxaro style pottery	PG and EG periods

Through time, it is possible that a settlement was completely abandoned and moved to a higher elevation, as happens with the cases of Serra del Palco Mandria and Monte Conca [La Rosa 1997b:197-202]. Serra del Palco Mandria, a site founded around the Middle Neolithic period, continued to be frequented until the initial phases of the Copper Age [La Rosa 1985, 475-482]. After a phase of abandonment, the area was newly occupied during the Early and Middle Bronze Age, namely the Castelluccio and Thapsos phases, [Palio 1997, Ardesia 2014, 159-160], but at a higher elevation, perhaps for defensive purposes. The contemporaneous movement of settlements from lower to higher elevations seems to be an indication of an organizational strategy of space capable of following precise logic over the centuries.

As for the previous phases, in the later stages of the Bronze Age and in the Early Iron Age, the territory of Milena appears to be affected by the circulation of ceramic product of Aegean type, a phenomenon that becomes a common cultural denominator for the prehistory of this area (Tab. 1).

2.2.1 The territory of Milena during the Middle Bronze Age

Of particular importance are the cultural dynamics characterizing the Middle Bronze Age, especially regarding the circulation of Aegean-type pottery and evidence of cultural encounters between the indigenous community and foreign agents.

Numerous Mycenaean-type remains have been documented in Sicily and along the Platani valley during the Thapsos phase [Tanasi 2005]. A new practice that breaks with past patterns for burial practices around Milena, linked to oven-shaped tombs or “grotticella” tombs, shows clear signs of interaction with the Aegean world. These new tombs imitate tholos tombs even if they were carved into the rock, being simply constructed in a positive rather than negative manner [Cavanagh & Laxton 1981, 109-140]. According to a different theory, the “grotticella” tomb with an ogival profile derives from circular huts, and thus the domestic sphere [Leighton 2015, 190-203]. In any case, returning to the former interpretation, the diffusion of Tholos-style tombs in Sicily develops within the heart of the island, especially around the area of Milena, Sutera, and Mussomeli. This was demonstrated by the findings at Monte Campanella, Monte Raffo, Monte Conca, the localities of Furnieddu, Mustansello, Pizzo Menta, Rocca Aquilia, Monte Ottavio, Rocca Piccirillo, and Rocca Ficarazze [Castellana 2002, 138]. This confirms that Aegean culture was able to permeate the Sicilian hinterland in a pervasive way, especially in the Platani valley. The theme of the relationships and circulation of Mycenaean ceramics in Sicily has attracted the attention of numerous scholars through the years. Davide Tanasi has carried out an in-depth survey of all Mycenaean pottery types and pottery imports present in Sicily [Tanasi 2020, 179-180]. They are principally located in coastal areas, with a few exceptions, like Milena, because products were able to make it into the hinterland following the course of rivers. This discussion is valid both for the circulation of products in ceramic and bronze. Many metal materials have been found along the Platani River, as seen in the case of Monte Campanella [D’Agata 1997, 452-456]. Here were found ceramics in the Thapsos style associated with two bronze basins, c. 13th century BCE [Tusa 1999, 494], two golden rings, and imported Aegean jewelry dateable to between the LH IIIB and the LH IIIC [Militello 1997, 190]. These objects ideally situate the area of Milena at the center of a large trade network coming from the Eastern Mediterranean. Aegean basins were similar to those found among the funerary goods at Monte Campanella and were also found in tombs near the

Agrigentine coast, such as those at Monte San Vincenzo di Caldare [AG] and Cannatello (AG) [Tusa 2012, 114].

The exploitation of sulfur mines in this period is well attested just a few kilometers from Milena, in the area of the town of Casteltermini (AG), where sulfur veins are documented in contrada Rovereto, the southern slopes of Rocca Ficarazze, and the valley of Mandravecchia [Gullì 2016:104]. Two very strategically important settlements were founded between the end of the Bronze Age and the beginning of the Iron Age: one at Rocca Ficarazze, a site on the bank of the Platani River, and one at Rocca Ferro, located on a well defended hill [La Rosa 1997e, 251-257]. The two settlements are important from a defensive point of view, considering that they control the Platani River from above, like the nearby settlement of Monte Raffe, which in turn controls the area between the Fiumicello and Belici rivers [Tomasello 1996:24; Congiu 2018a:19-21; Congiu 2018b:426]. The presence of sulfur deposits near Rocca Ferro, specifically in a small valley to the northeast of the hill where a small village also stood [La Rosa 1997e, 253], suggests that sulfur extraction was one of the principal activities in the area during this period. The existence of multiple centers for sulfur extraction, which then had to be transported from the interior to the coast for market, implies that local populations needed well-organized transit routes to transport the products efficiently. Therefore, it is possible to hypothesize the existence of routes that were used to transport the raw material considering both the technical limitations of the period and the advantages that the use of the Platani River could offer. It is important to consider the data that have emerged a few dozen kilometers south of Milena. During the Bronze Age sulfur was extracted and processed at Monte Grande [AG] and Palma di Montechiaro (AG) [Castellana 2002:44-49]. The discovery of materials imitating Mycenaean products in the Milena area, as observed by Tanasi, suggests two possibilities: either indigenous potters specialized in producing Mycenaean-style wares locally, or Mycenaean individuals had settled on the island of Sicily during the Middle Bronze Age. [Tanasi 2020:198].

2.3 Issues with routeways in the territory of Milena in the long term

The territory of Milena, extensively studied by Ernesto De Miro [1997] and Vincenzo La Rosa [1997] between the 1970s and 1990s, is located in a fertile area of Sicily that is rich in water and has long been inhabited and exploited for agriculture. The presence of rivers and streams has facilitated contact with other areas of the island via river valleys thus stimulating trade. Its central position and favorable geomorphological conditions made the area a crossroads for numerous cultures, which, over the millennia, exploited the natural passages that led from the coastal areas to its interior. However, all these paths are still hypothetical for the time being, and difficult to identify with precision due to the absence of material evidence.

This represents a problem concerning not only the pre-Classical routeways of the island but also the Greco-Roman route system through the medieval period. Like the rest of Sicily, the most secure reference points for viability come from ancient sources and archaeological remains from the Roman period. The principal sources are the Itinerarium Antonini and the Tabula Peutingeriana [Uggeri 1986:91-93]. They are very useful tools, but they often provide approximate and incomplete data. Consequently, we know of areas of ingress and cultural exchange on the island, but the paths and roads used over the millennia themselves have not been perfectly identified. The principal Sicilian roads are dated to the Republican Roman period, as demonstrated by one of the few miliaria found in

Sicily, which dates between 252 and 248 BCE. This was discovered along the via Aurelia, which linked Palermo and Agrigento. [Uggeri 198: 90-94]. These routes were likely used during the Greek period as well.

During the Middle Ages, the close correspondence that was created between urban structures and defensive functions [Maurici 1992, 42] would create the necessity to create new pathways. It was essential to favor speedy movement to defend strategic agricultural areas of the island. As a consequence, new route systems arose that exploited the heights of hills rather than the coastline, which was used by the Roman network of roads [Arcifa 2005; Arcifa 2009]. This argument becomes even more incomplete when it comes to the prehistoric period, given the total absence of literary sources. To address these lacunae, therefore, it is necessary to employ other methods of inquiry. The area of Milena represents an excellent case study, considering the contour of its territory, its morphological characteristics, and its low levels of human modification. Numerous studies analyze how geological factors have influenced the choice of settlement locations [Forciniti & Salerno 2003:15-18; Quilici 2015:149-162].

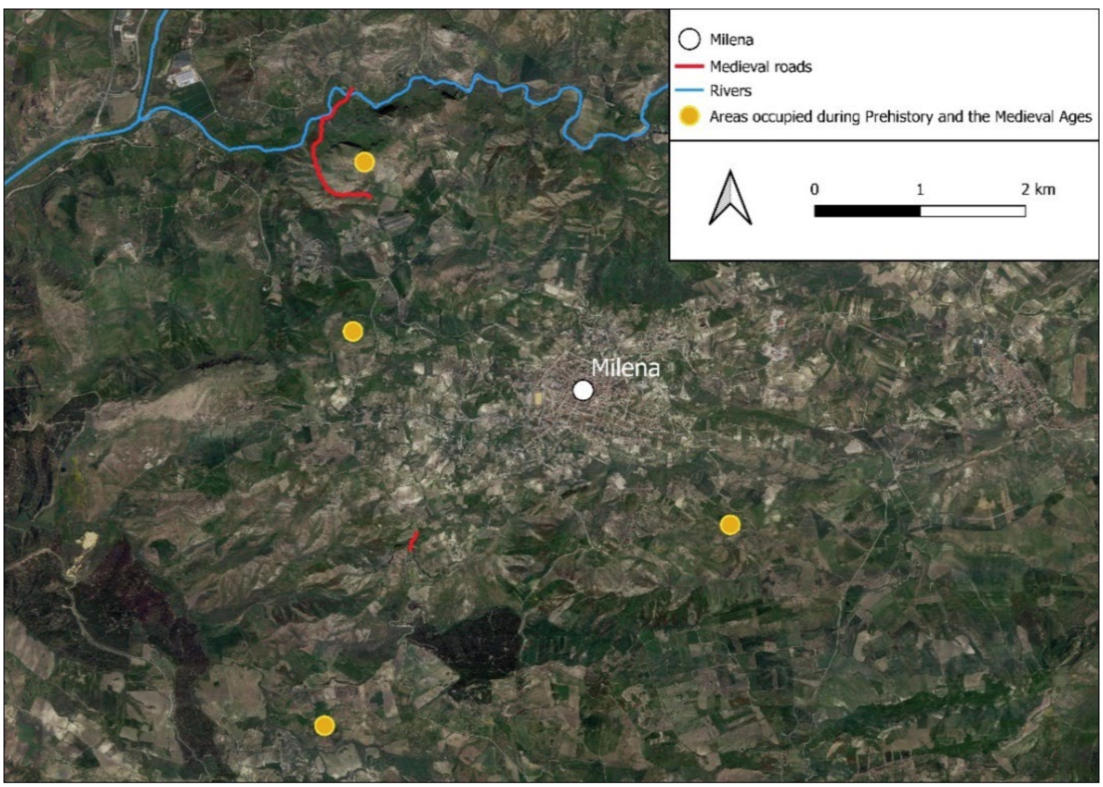

Figure 2 - Superimposition of locations of Medieval and Prehistoric archaeological remains and known medieval road system over the topographical map of Milena and its surroundings, according to the medieval studies of Lucia Arcifa. Generated from Google Map data ©2015.

Various studies have also already addressed the routes that linked the central-northern areas of the island with the Sicani mountains in historic periods, especially in the areas around Milena [Uggeri 2004, 106-108; Arcifa 2005, 31-33]. Numerous archaeological sites from the medieval period are known in the area of Milena. The majority of these sites correspond to an area in which there is also well documented evidence for prehistoric contexts [Fig. 2], as is the case in the localities of Monte Conca, Amorella, Zellante, and Rocca Aquilia [Arcifa 1997; La Rosa 1997d:153].

More data comes from the study of the Magna Via Francigena, a path that still connects Palermo with Agrigento and on which hundreds of pilgrims periodically pass by foot through the Sicilian interior [Scionti 2024]. Pilgrims walk through the municipality of Milena and then in proximity to archaeological areas. Many of the prehistoric archaeological sites, in fact, overlook precisely what has been documented as a medieval road axis that some scholars identify as the very same Magna Via Francigena [Comunale 2017, 73-87]. According to other interpretations, however, it is instead a medieval path called the Sutera-Grotte [Arcifa 1997:283-288; Rizzo 2004]. The latter was a route capable of connecting the coastline of Palermo with that of Agrigento, passing through the medieval village of Castronovo (PA), and then proceeding south towards the center of Sutera, the hamlet of Milocca, and the villages of Racalmuto (AG) and Grotte (AG) [Arcifa 2005]. The route, which passed through the current municipal area of Milena, consequently passed through the localities of Monte Conca, Amorella, and Zellante, where an overlap of prehistoric and medieval sites has been observed. The importance of this route is on account of its ability to connect Agrigento and Palermo by crossing the Gallo d'Oro River rather than the Platani, rendering the passage easier and safer, even though it comes at the expense of the brevity of the route.

We utilized QGIS software for LCP landscape analysis to disprove this theory. In GIS applications, the "least cost path" (LCP) calculates the most efficient and convenient itineraries between two points based on terrain characteristics [Alberti et al. 2022; Alberti 2017; Tang and Dou 2023]. After conducting an LCP GIS analysis, we have determined that the best North-South passages in Sicily are located close to the Gallo d'Oro River and in the Municipality of Milena. If you are heading towards the West, it is advisable first to reach the Milena territory and then follow the course of the Platani River [Fig. 3].

The problem of crossing the Platani river, located further south than the Gallo d'Oro, has remained relevant into modernity. In the mid-19th century, an attempt was made to build a bridge at Passo Funnuto, located at the convergence of the Platani and the Gallo d'Oro rivers. This bridge, built in 1863, collapsed only 10 years later [Arcifa 1997:286], demonstrating how complex the crossing of this area has been even for modern engineers. It is assumed that the medieval road, heading to Grotte, passed at the more peaceful Gallo d'Oro River nearby the aforementioned Monte Conca, whose summit unsurprisingly housed the remains of a fortification dating to between the 11th and 12th centuries along with prehistoric archaeological finds [Arcifa 1997:287]. The medieval road was probably the descendant of an even more ancient route of Greco-Roman origin between Palermo and Agrigento [Uggeri 2004, 13-19, 97-116]. A great deal of evidence from the Roman period has been documented in the area [Mandruzzato 1997:257-262]. All the sites that then became the main stages of the Roman-medieval road system in the area show signs of having been frequented in prehistory as well, beginning in the Middle Neolithic. If medieval sites stood near a routeway to keep it in sight, then it cannot be excluded that prehistoric habitation sites did the same for an even more ancient route.

Ultimately, the reconstruction of the anthropic landscape [Tilley 1994] is a complex operation. The case of Milena is optimal because, more than anywhere else, there is a copious amount of data on the circulation of materials, the distribution of settlements, and the extraction of raw materials. Without written sources, it is difficult to define the dynamics and paths of a trade network, and the resulting route systems connected to it.

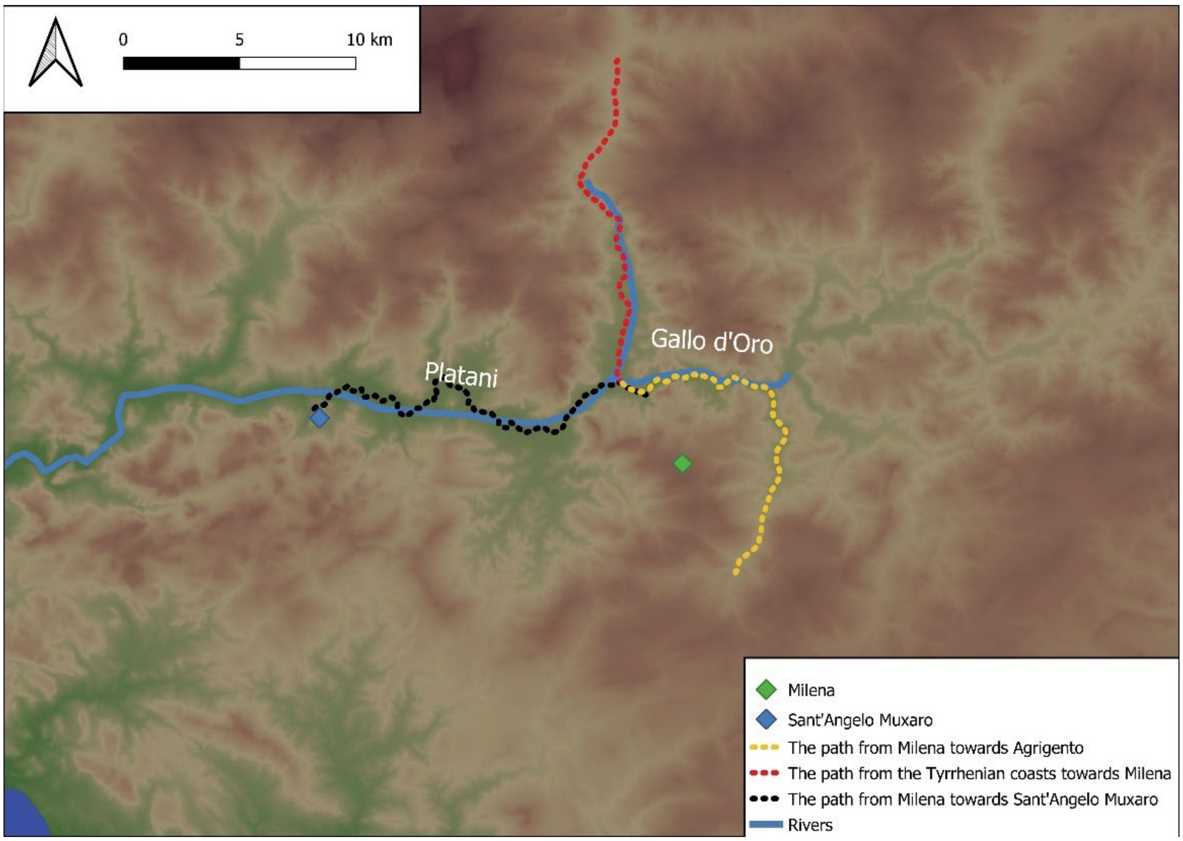

Figure 3 - The optimal paths according to the Least Cost Path (LCR) analysis. Colorized version of the DEM from Tinitaly DEM made available by the Sezione di Pisa Istituto Italiano di Geofisica e Vulcanologia [Tarquini et al. 2007; 2023].

However, the material culture evidence within an area can provide an important aid, at least for the definition of a pattern [Tanasi & Vella 2014, 67-68], and to obtain a picture of its main axes.
Therefore, this study analyzes the material conditions of the life of prehistoric societies and develops various research questions. The first concerns the possibility or lack thereof to reconstruct the relationship between human communities, and between those communities and nature. Then, the detailed study of a single site passes on to the analysis of larger areas, considering the landscape a witness to the past and still bearing traces of its history and transformations [Giannitrapani 2021, 487]. The landscape under study is seen as the result of a continuous process of stratification, constant through the ages, from remotest antiquity to the present [Cambi 2015, 245]. Another

important question related to the study is understanding whether the analysis of the diffusion of materials over millennia allows for the reconstruction of the distribution of settlements and the degree of their interrelationships between one another based upon the chronological period. Consequently, is there uniformity of thought behind the settlement choices in the area of Milena across millennia? Starting from these questions, the final objective of the study is to identify the paths used by local prehistoric communities to attempt to understand whether there is a common thread going back in time that can help researchers identify natural passages for the paths used by inhabitants from the Middle Bronze Age to the Middle Ages.

To answer these research questions, specific methods were adopted. First of all, during the numerous and long-lasting survey activities, a drone was used to map all the areas under investigation in detail. Subsequently, the resulting orthographic images were imported into a GIS to enhance the granularity of the research through the creation of specific maps. Thanks to remote sensing, it was ultimately possible to reduce research time and identify archaeological contexts more easily.

3. METHODS

3.1 Use and contribution of UAV technology

The fieldwork component of the study mapped the archaeological areas in the territory of the municipalities of Milena, Campofranco, Mussomeli, and Sutera, regardless of the historical period of reference (Fig. 5). The goal was to generate an archaeological map of the hinterland of the region [Buscemi et alii 2014, 135-137] including all archaeological evidence from the prehistoric period, through the Greco-Roman period, to the Byzantine and Islamic periods.

The surveys were carried out with a DJI Phantom 4 PRO V2.0. Aerial photogrammetry was performed with a drone [Piccareta & Ceraudo 2000, Ferrari et al. 2015, Piani 2013 6-10] and the data it yielded was subsequently used to create the DEM and orthophotos to be inserted into a GIS platform for the creation of topographical surveys [Buscemi et al. 2014:149-153]. Survey activities led to the identification of several areas that showed various quantities of prehistoric and protohistoric ceramics already on the surface. The flight plans were realized based on the characteristics of the land [Minucci 2018:65-96]. The parameters of the flight plans were set to generate photogrammetric streaks with an overlap of 60% and a side lap of 20% [Pulighe 2009, 18-19]. Through post-processing of the photogrammetric images [Zhang et al. 2019:807-827] it was then possible to generate 3D visualizations of the territory. The principal software used consisted of Agisoft Metashape and 3DF Zephyr. The datasets consisted of between 60 to 1100 photos (Tab. 2).

Point clouds were generated after the initial alignment of the images (Fig. 4a). Finally, the polygonal mesh was generated (Fig. 4b), and textures were applied. Furthermore, it was possible to generate a short report on the precarious conditions faced by the archaeological sites and the hills themselves. Subsequently, orthophotos and DSMS were extrapolated to be inserted into the GIS platform (Fig. 4c).

Tab. 2: Report of Drone flights carried out between 2020 and 2021.

Dataset	Capt. Year	Area [m2]	Alt [m]	N. Pics	Orthoph. Res. Cm/Pix.
Monte Conca Carruzzata	2020	11.500	39	112	1.02
Monte Conca Ovest	2020	15.700	38.7	135	9.99 mm/pix
Monte Conca Vigneto	2020	7.000	41	175	1.29
Mustansello	2020	78.000	35.8	672	9.71 mm/pix
Serra del Palco	2020	11.000	42.5	65	1.46
Serra del Palco Mandria	2020	5.000	36.8	61	1.13
Amorella	2021	15.000	38.8	400	9.87 mm/pix
San Paolino	2021	15.000	46.3	104	1.43
Mezzebi	2021	25.500	50	278	1.29
Rocca Ranni	2021	50.000	70.9	100	1.95
Monte Grande	2021	40.000	65	270	1.63
Baruna	2021	76.000	84.3	209	2.09
Zellante	2021	112.000	42.5	1130	1.08
Rocca Aquilia	2021	25.600	36	431	9.02 mm/pix
Cimicia-Finaita	2021	10.300	38.6	200	9.88 mm/pix
Pirito	2021	9.800	31.4	85	9.51 mm/pix
Raffo-Zazzi	2021	45.000	43.4	224	1.08

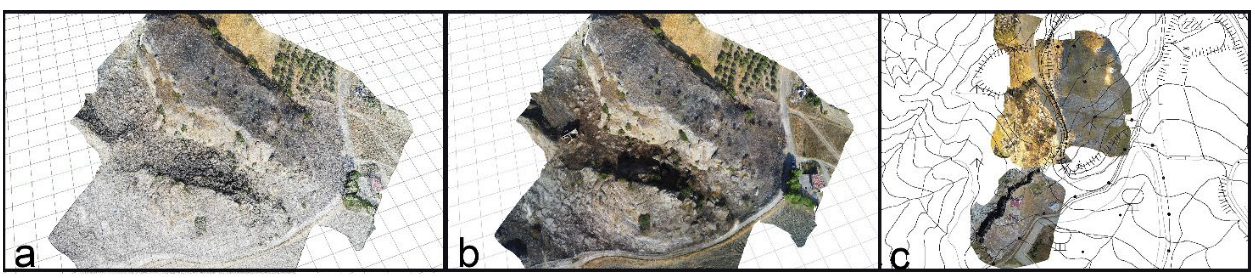

Figure 4 - The different phases of processing 3D aerial photogrammetry data captured with a drone: a) dense point cloud; b) mesh; c) Orthophoto inserted in the GIS system on CTR of the Sicily Region.

3.2 Use and contributions of GIS applications

The exact identification of archaeological areas and their relationship with the geomorphology of the region was obtained by inserting the orthophotos generated by the 3D models into a GIS environment. The creation of GIS systems allows the management of topographical, cartographic, and spatial information regarding the archaeological evidence present in a landscape [Salzotti 2009:1-26], as well as other types of analysis on a DEM, and the study of levels of intervisibility among the surveys distributed in the area under research [Acconcia & Ferreri 2016:179-188]. First, the orthophotos of the technical cartography [CTR] at a 1:10,000 scale of the municipalities of Milena, Campofranco, Sutera, Montedoro, and Mussomeli (all towns located within the Caltanissetta province) was conducted using the open-source software QGIS. The transition from 3D documentation, typical of the models described above, to 2D digital documentation offered the possibility of applying the raster and vector themes necessary so that all the surfaces of interest could be characterized [Floris et al. 2017], and therefore detected. The goal was to "break down" the natural landscape, its geomorphological characteristics, and various constituent elements through the GIS platform [Russo 2018:375-389] in such a way as to be able to observe and study with precision every single characteristic of the territory. To make the GIS dynamic and queryable, tables were generated containing associated information on the archaeological contexts with their vectors.

3.3 Use and contribution of satellite remote sensing

The creation of a specific GIS portal made it possible to relate the geomorphological aspects of the landscape with the areas containing archaeological evidence. Of the numerous prehistoric settlements surveyed, less than half have been excavated to date. Furthermore, in some cases, almost 30 years have passed from the moment of discovery to today. Since then, layers of earth and vegetation have completely covered the remains of previously reported prehistoric huts. For this reason, it is very difficult to identify the remains of ancient settlements, especially considering that some of these contexts are spread over several hectares. To effectively carry out the work, an interdisciplinary team was created [Brogiolo 2017] with different approaches and solutions. Their involvement allowed the collection of data through satellite remote sensing and led to the identification of new sites completely covered by meters of earth and vegetation, otherwise impossible to observe with the naked eye.

In detail, thirteen bands of Sentinel-2 multispectral images with a spatial resolution between 10 and 60 meters were generated. Sentinel 2 data were processed using QGIS software, which includes the Semi-Automatic Classification Plugin (SCP) option [Calderone et al. 2022]. This plugin permitted the download of remotely sensed images, in this case, the Sentinel-2 dataset, and applied processing phases and performed supervised classification [Mangiameli 2018]. The procedure adopted for the identification of archaeological evidence involved the use of multispectral images that were geometrically and radiometrically corrected. Subsequently, the satellite images were pre-processed to facilitate visual interpretation and make the identification of archaeological sites easier [Gennaro et al. 2019; Mangiameli et al. 2020].

By combining the production of orthophotos through 3D digitization of the area with drone surveys and remote sensing, it was possible to identify two new settlements in the localities of Mustansello and Cimicia Finaita [Calderone et al. 2022]. Thanks to the identifications generated by analysis of the satellite imagery, it was then possible to notably reduce the areas containing the possible presence of huts, from three hectares on average to approximately 0.150 hectares at the end. In this way, by observing the data collected in the field during the survey activities with those that emerged from the satellite images (that were subjected to filtering), it was possible to precisely isolate the exact space in which the remains of the prehistoric huts are located.

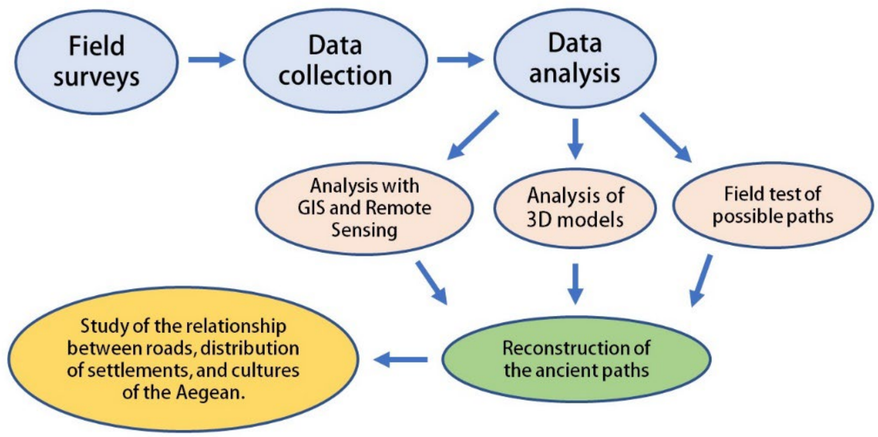

Figure 5 - Diagram showing the research workflow used.

4. RESULTS OF STUDIES ON THE ROUTEWAYS

Numerous survey activities have demonstrated that, even up to the modern period, roads were constructed in harmony with the course of mountain ridges and hills. The paths cross the territory of Milena in such a way as to avoid crossing the most dangerous rivers, such as the Platani, and take advantage of the small valleys located at the foot of the most imposing mountains. Even today, groups of pilgrims cross this territory on foot, walking from Palermo to Agrigento using the Magna Via Francigena. Many studies analyze how geological factors influence the placement of settlements (Forciniti & Salerno 2003, 15-18; Quilici 2015, 149-162). The study of the interaction between human activities and the physical environment is fundamental. In the geology of the environment, skills derived from the Earth Sciences are intertwined with those of the social sciences [Laureti 2019, 685]. This approach allows for evaluating how the environment influenced anthropic choices throughout history, as well as the changes human groups made to shape the landscape. The end goal is to define the evolution of the landscape in all its aspects [Tarlano 2014, 285-296]. During this research, it is possible to observe and isolate several moments in which the communities that lived in the area of Milena managed to replace one other, creating continuity in the same places. In this work, all the characterizing factors present in the area will be analyzed, starting from geomorphological elements up to the diffusion of imported products.

4.1 Routeways during the Middle Bronze Age

Based on the data collected for the Middle Bronze Age, it is possible to identify two routes through the territory of Milena. The first, proceeding from the north through the Sicani mountains, traverses the Gallo d'Oro River; it then deviates towards the West and rejoins the course of the Platani River. The second, crosses the Gallo d'Oro and follows the course of the older route used during the medieval period [Arcifa 1997, Comunale 2017] (Fig. 6), but likely also during the Middle Neolithic, which crossed the locality of Serra del Palco Mandria and headed toward the South in the direction of Grotte [AG] and the beaches of Agrigento [Calderone 2021] (Fig. 6).

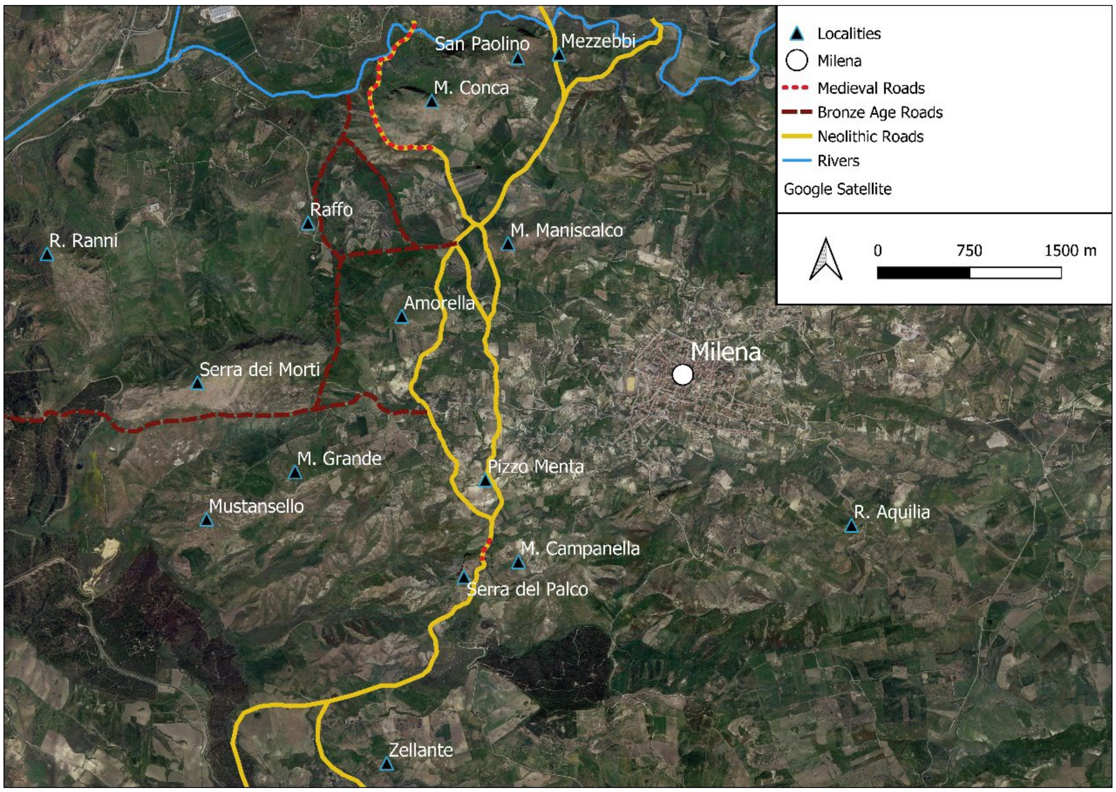

Figure 6 - The hypothesized routes through the territory of Milena during the Neolithic, the Eneolithic, the Bronze Age, and the Middle Ages. Generated from Google Map data ©2015.

There is a great deal of evidence that could show the presence of ancient pathways. About 3 km to the north of the Gallo d’Oro River, near Sutera in the Contrada of San Marco, the remains of a village of huts and Bronze Age “a forno” burials are documented [Regione Sicilia 1999; Palio 1997:114-115; La Rosa 1997c, 200-201], as well as an indigenous necropolis of the 8th century BCE with artificial “a grotticella” burials [La Rosa 1997e:251]. This area can be considered a crossroads for the numerous pathways that would have led from the Tyrrhenian coast to the Milena region, which shows signs of frequentation during the Iron Age and the Byzantine period. [Regione Sicilia 1999] (Fig. 7). It is a rugged hill that overlooks the nearby route used even today by pilgrims who are walking the Magna Via Francigena in the direction of Monte Conca, and consequently the convenient crossing of the Gallo d’Oro River at the so-called Roman bridge. In this instance as well, a prehistoric settlement overlooks the same possibly medieval but surely contemporary road system, as is demonstrated by the transit of the pilgrims.

Farther to the south, the areas occupied by Neolithic settlements continued to be used in successive periods. At the same time, between the end of the Eneolithic and the beginning of the Bronze Age, new settlements were founded overlooking the valleys, such as at Monte Conca and the crossing of the Gallo d'Oro River. More signs of Eneolithic frequentation of the area come from Monte Conca and Monte San Paolino, as attested by the ceramics found in the styles of San Cono-Piano Notaro, Serraferlicchio, and Malpasso [Maniscalco 1997, 63-72]. Meanwhile, the area of Mezzebbi shows signs of frequentation from the beginning of the Bronze Age, with ceramic finds in the style of Castelluccio [Privitera 1997:85-92; Ardesia 2014:102]. Like the latter case, Monte Conca and San Paolino continue to show signs of occupation in the Early Bronze Age, with settlements located in the same areas as previous periods [Palio 1997:111-116] (Fig. 7). Beginning in the Bronze Age, many of the heights that overlook these aforementioned mountains and the Gallo d'Oro River are systematically occupied.

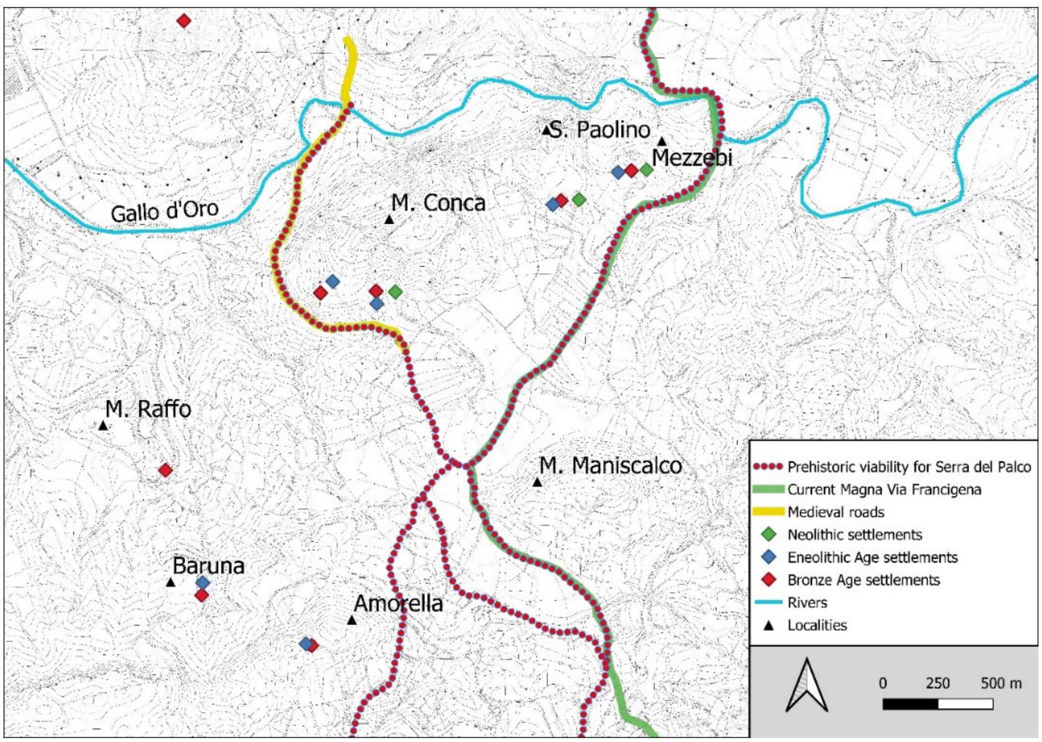

Figure 7 - Distribution of settlements from the Neolithic, Eneolithic, and Bronze Age. The hypothesized viability of prehistoric pathways compared to the current Magna Via Francigena and Medieval routes. CTR of the Sicily Region, scale 1: 10.000.

Furthermore, immediately before crossing the aforementioned river and when coming from Sutera in the direction of Campofranco, one passes through a narrow valley dominated by the hill known by the locals as Chiertasì, located in front of Monte Conca and less than 900 meters from it (Fig. 8). New evidence of habitation of the site has been reported exactly on the top of the outcrop in question, one of the most difficult to climb in the area, and from the summit of which it is possible to see the whole area in all directions, with particularly good coverage of the Western areas, i.e., in the direction in which the Gallo d'Oro River flows and converges into the Platani River.

Figure 8 - The area between the villages of Sutera and Campofranco around the Gallo d'Oro River. Generated from Google Map data ©2015.

After passing Chiertasì and crossing the Gallo d'Oro at the improperly named Roman Bridge, one passes along a trail that crosses the Western slope of Monte Conca. Once past it, a flat area begins to form between Monte Maniscalco to the East, Rocca Amorella to the South, and the hull of Raffo and Pernice to the West. These environments form a belt within which the most important roads leading to Milena can still be found, such as Provincial Road 24 (SP24). This demonstrates how strategically viable this area remains to this day. Precisely from the beginning of the Middle and Late Bronze Ages, evidence of the frequentation of in the localities of Pernice, Raffo, and Baruna have been reported, as is attested by the discovery of Castellucciano and RTV style ceramics [La Rosa 1997c, 197-202; Ardesia 2014, 102], which are present in large quantities on the surface of the soil. These areas are located in perfect succession, almost perfectly aligned, about 700 meters apart from each other. These locations are also perfectly visible to each other and can be viewed from both Monte Conca to the north and Rocca Amorella to the South. In practice, the sites occupy a stretch over 2 km long along the route between the Gallo d'Oro and Rocca Amorella, and all of them overlook the modern SP24. In this case, the geomorphology of the territory seems to speak clearly. Three hills have hosted sites that control the flatlands between the Gallo d'Oro River and the modern population center of Milena following the gently sloping and easy to traverse land at their feet. Therefore, it is possible to imagine the existence of a route reachable both from the crossing of Monte Conca, as well as the other river crossings closer to the SP24, as still happens today.

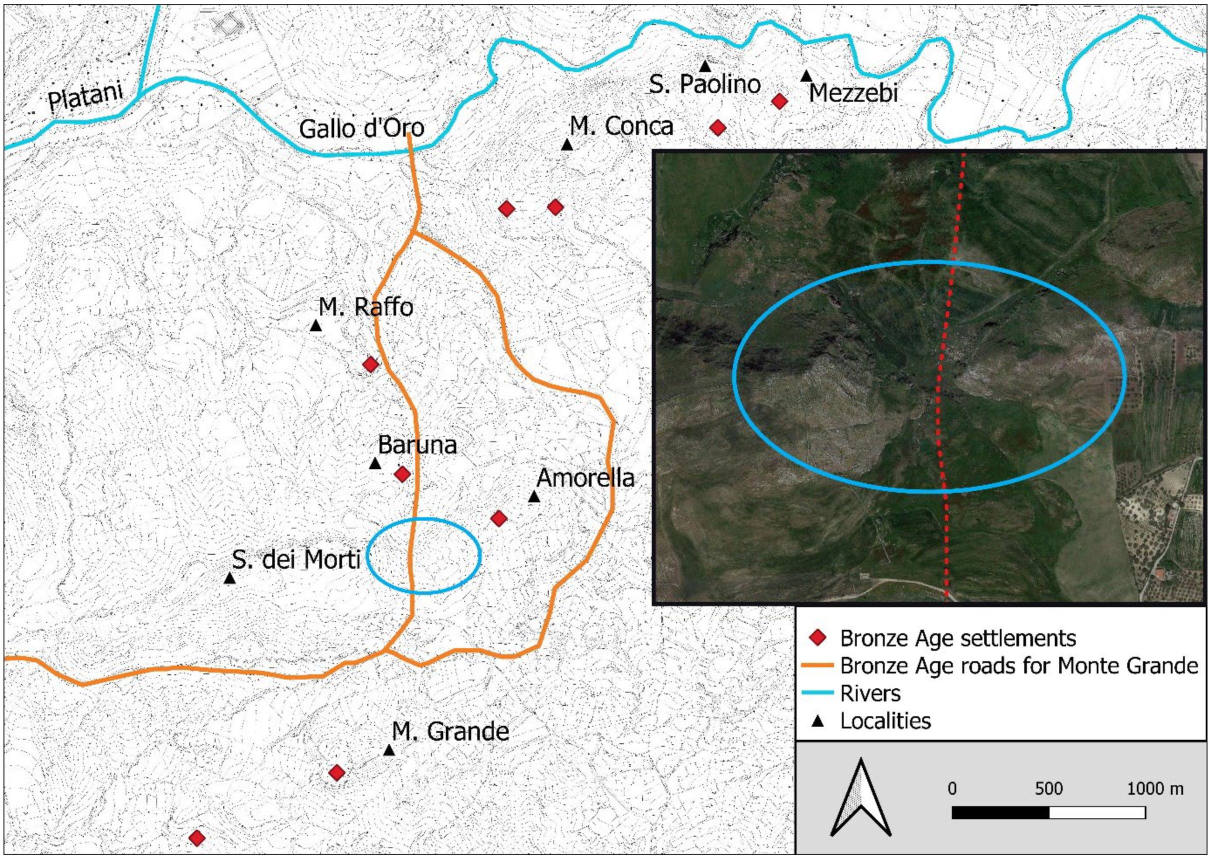

Figure 9 - The hypothesized system of paths in the direction of Monte Grande starts from the Gallo d'Oro crossing point in the locality of Chiertasì. Details of the crossing area between Baruna and Amorella. CTR of the Sicily Region, scale 1: 10,000. Image generated from Google Map data ©2015.

Another feature of the area relates to the fact that Baruna, the southernmost hill of the three mentioned above, rises right at the foot of Serra dei Morti, and in front of Rocca Amorella (Fig. 9). In practice, geomorphologically speaking, the hills of Serra dei Morti and Rocca Amorella are facing each other and meet; they slope more or less rapidly until they reach a flat area a few tens of meters wide, which forms a bottleneck separating the two. The locality of Baruna occupies the space to the north of the aforementioned bottleneck, which is easy to cross and free of obstacles. This allows one to proceed in a southerly direction without having to climb the rugged slopes of the Monte Serra dei Morti and Monte Rocca Amorella. Furthermore, the narrow pass serves as the entrance to the valley between Serra dei Morti and Monte Grande and is just 300 meters south of it in a straight line. It is possible to easily return to the path, largely unpaved to this day, which leads straight and downhill to the prehistoric settlements of Monte Grande and Mustansello, which were highly frequented during the Copper and Bronze Ages. [La Rosa 1997c:197-202; Maniscalco 1997:63-72; Palio 1997:111-116]. Based on the data presented here, it seems clear that there was a path that, after passing the Gallo d'Oro River, proceeded in the direction of Monte Grande toward the western part of the island, passing across Mustansello to then rejoin the course of the Platani River, which is about 2 km away (Fig. 10).

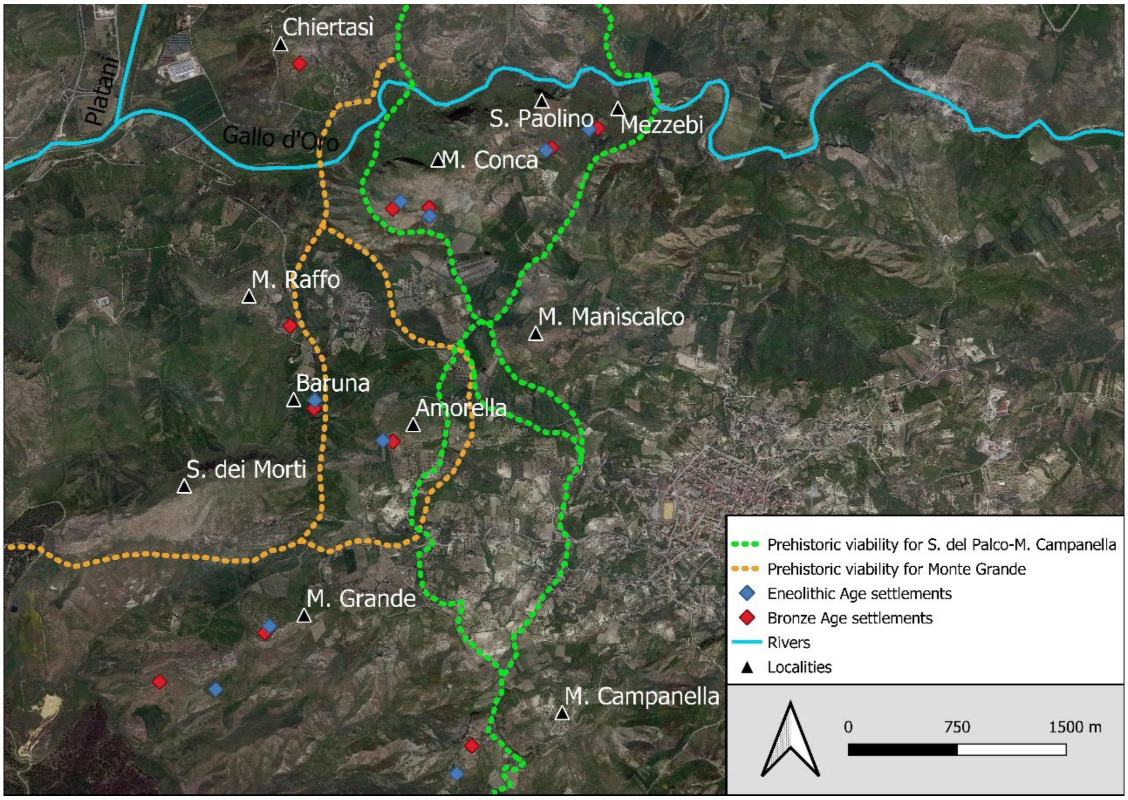

Figure. 10 - The hypothesis of the viability through the territory of Milena between the Eneolithic and the Bronze Age in the direction of Monte Grande and Serra del Palco. Generated from Google Map data ©2015.

Starting again from the Gallo d'Oro River, it is possible to identify a second route headed South in the direction of the locality of Serra del Palco. Indeed, having established the continual habitation of Monte Conca, Monte San Paolino, and Mezzebi, heading to the South and following the path described, Rocca Amorella also continues to be occupied, where Castelluccian and RTV finds have been documented [Ardesia 2014, 102]. This is also the case for Pizzo Menta, which continues to be occupied at least until the end of the Copper Age, as the presence of ceramics in Malpasso style show [Maniscalco 1997, 63-72], but also during the Bronze Age, given the presence of a Tholos tomb [Castellana 2002, 138]. Evidence of the site's use is well documented on the summit of Serra del Palco where a Bronze Age village developed [Ardesia 2014, 159-160], but most importantly, new burials were created on Monte Campanella, with particular regard to the Tholos tomb B, where the aforementioned Mycenaean imported ceramics were found [Tusa 1999, 527]. Finally, even the locality of Zellante, which ideally represents the southernmost part of the route, continued to be settled from the Copper Age to the Middle Bronze Age [Maniscalco 1997, 63-72; La Rosa 1997c, 197-202].

5. DISCUSSION

Compared to the Neolithic period and the beginning of the Copper Age [Calderone 2021], settlements increased in the direction of Monte Grande. Passages were exploited that, before the Bronze Age, based on the data collected to date, did not show the signs of frequentation as are seen in the cases of Baruna, Pernice, and Raffo. The difference compared to the Neolithic period or the Early Copper Age is that, in addition to the route towards Serra del Palco that was exploited during the Greco-Roman and Medieval periods, a new path towards Monte Grande was formed. This new route passes from Pernice, towards Baruna, and then towards Monte Grande and Mustansello. Subsequently, it probably continued towards the western part of the island, following the course of the Platani to Sant'Angelo Muxaro [Palermo 1999, 2004], a location that can be seen from Monte Grande (Figg. 3, 10, 11). Perhaps the increase in the number of settlements is due to the growth of commercial contacts between Sicily and the rest of the Mediterranean. In an area rich in resources like the one under study, these contacts create a need for increased exploitation of the region. The idea of contact between this area and the Aegean is sustained by the presence of Tholos tombs, which are very rich in the area of Campofranco, Milena, and Mussomeli [Tomasello 1996:112-148]. All the Tholos tombs documented in the area are near the possible paths that have been identified thus far, both the one heading towards Serra del Palco and the one towards Monte Grande (Fig. 11).

It is possible that the area of Milena represented a center that acted as a catalyst for products, ideas, and architectural forms. Milena was at the center of multiple communication networks due to the extensive trade through the hypothetical "via del Platani," which was capable of connecting the southern areas of the island with its Tyrhennian coast [Tusa 1994, 333-347]. Contact with the Agrigentine coast is strengthened by the discovery of materials imported from the Aegean, particularly Cypriot basins dated to the Late Bronze Age. These basins were found at Milena, Caldare, Sant'Angelo Muxaro, and Cannatello (AG) [Tusa 2012, 114]. This indicates gradual ingress into the hinterland, especially considering that Cannatello is located near the coast, while the site of Caldare is further north into the interior of the island, about halfway between Cannatello and Monte Campanella.

According to some interpretations, Cannatello was a Thapsian emporium of the Middle Bronze Age that controlled sulfur trade [De Miro 1999; Castellana 2000, 165]. It was probably a settlement with a commercial function or a destination within the trade routes from the Aegean towards Sardinia and vice versa [Russel & Knapp 2017]. The presence of ceramics and tombs has been documented at Caldare [Bernabò Brea 1958:129-131], consisting of a Castelluccian period village that shows signs of frequentation in the later Thapsian facies as well [Tusa 1999, 494]. Once again, the presence of a tomb with imported Mycenaean material and other products dateable to the Thapsian facies, as well as two bronze daggers dated to the Middle and Late Bronze Age were documented in the area [Bernabò Brea 1958:131]. Within the same tomb were found two bronze basins, one of which was of Cypriot manufacture, dated to the 13th century BCE [Tusa 1999:494]. The grave goods yielded at San Vincenzo share the same chronological sequence as the Aegean bronze found in the tholoi of Milena [La Rosa 1997a, 246]. Furthermore, although the context is damaged, the tomb documented at San Vincenzo could also be considered a full tholoid tomb in its own right [La Rosa 1979:78]. San Vincenzo, then, also appears to share a similar context with Milena, as evidenced by the same types of tombs and grave goods within the same chronology.

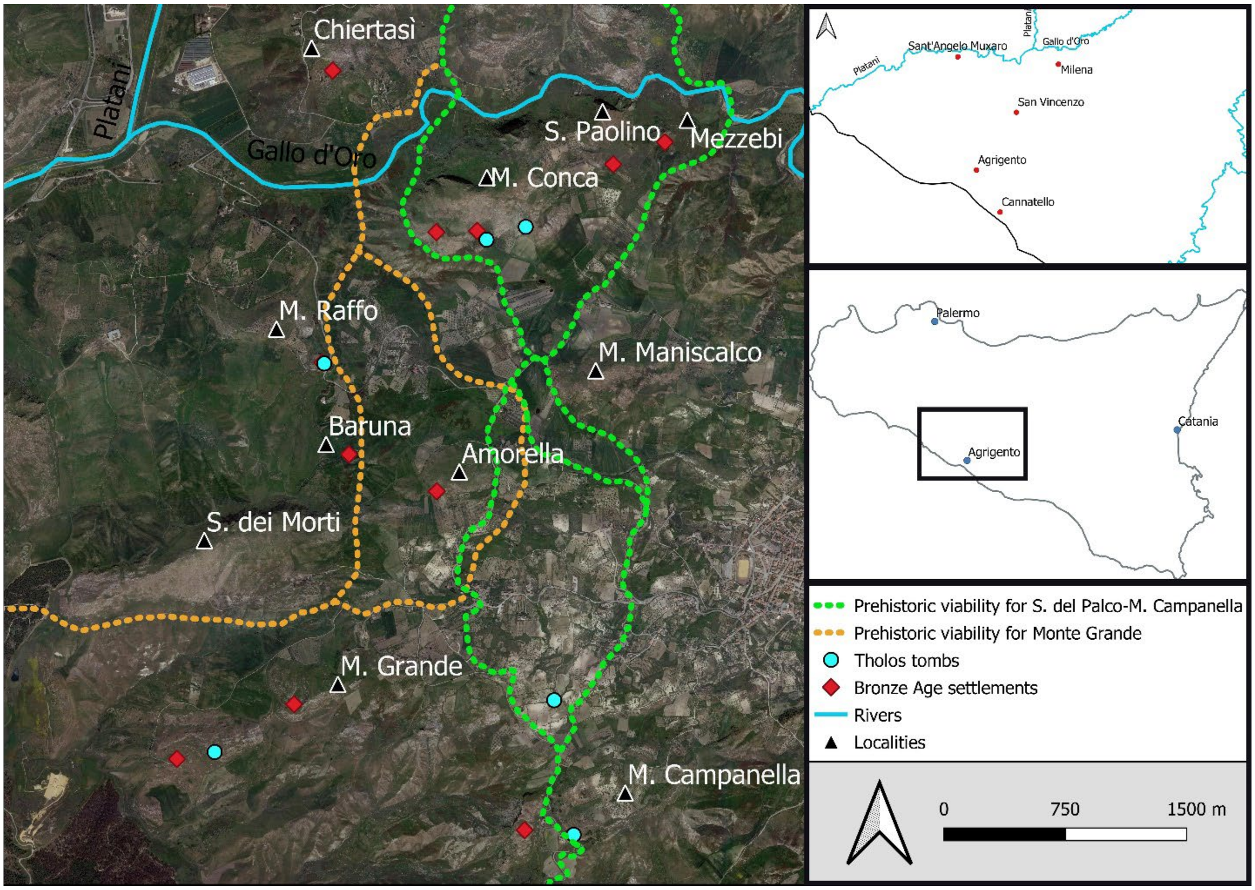

Figure 11 - Distribution of the Tholos tombs in the Milena area compared to the system of paths. Generated from Map data 2015 ©Google.

At Contrada Capreria (Sant'Angelo Muxaro – AG) two basins within a tomb were found, both of which were very similar to those found at Caldare and Milena [Castellana 2000, 212]. The diffusion of tholos-type tombs is also well documented at Mustansello [La Rosa 1997b:153] (Fig. 12). The burials are located on the southern side of the hill and in proximity to one another on one of its slopes as well as scattered along its ridge. The area is particularly advantageous for the foundation of a settlement, considering the high degree of interconnectivity and intervisibility between the mountains and hills such as Monte Grande, Pizzo Menta, Serra del Palco, Amorella, and Pernice.

Multispectral analyses were undertaken in the area corresponding to the foot of Mustansello that highlighted the existence of a village of huts that were well hidden under piles of earth, debris, and vegetation [Calderone et al. 2022]. This last hill, thanks to a discrete network of paths, some of which were dug out of the very friable rock, is perfectly connected with the adjacent Monte Grande. From its summit, it is possible to monitor the territory in the direction of Serra del Palco and Sant'Angelo Muxaro, the peak of which is perfectly visible. In essence, it is an area that at least appears to be very favorable for settlement, as it presents notable advantages both in terms of its defense and its interconnection with other inhabited hills in the area, such as Pizzo Menta and Serra del Palco. Furthermore, another important element, related to its inhabitability, is the well-documented presence of water, which is largely guaranteed by two different springs [Saia 1997:24].

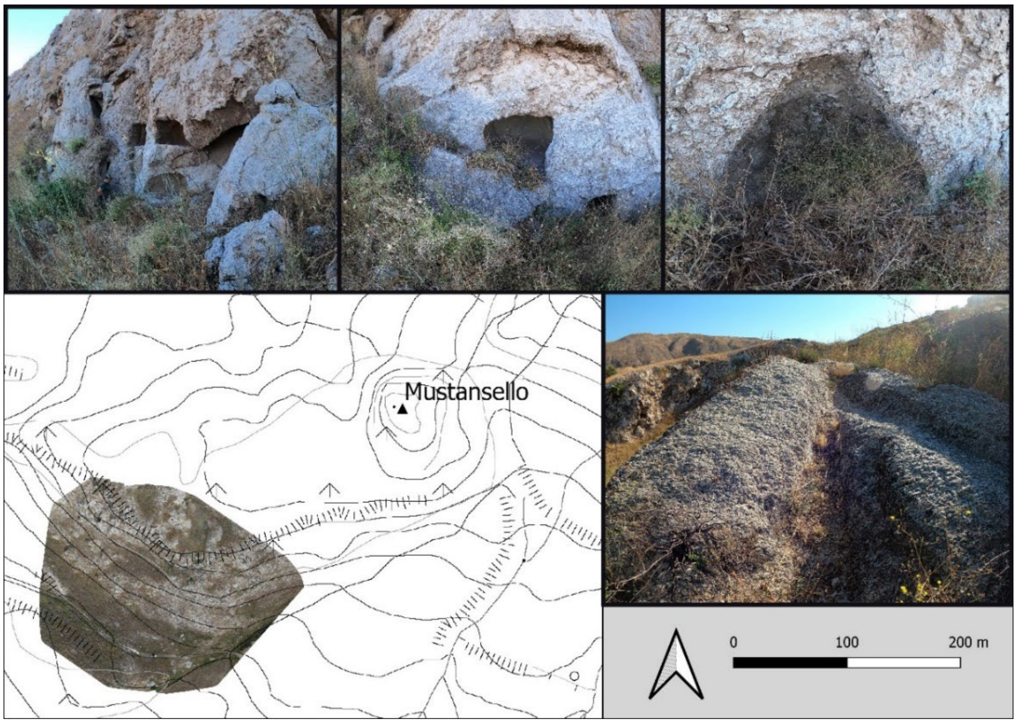

Figure 12 - Orthophoto of the locality Mustansello on the CTR of the Regione di Sicilia. In the area of the orthophoto, there are the Tholos tombs and paths carved into the rock.

The widespread presence of tombs demonstrates that the area was important in the Copper Age and especially in the Bronze Age. The ceramic finds in the caves between Monte Grande and Mustansello show a clear continuity in the occupation of the area that demonstrate the frequentation of these contexts from the Middle and Late Copper Ages through the Middle and Late Bronze Ages. The passage of ideas and products through the territory of Milena is well attested by the appearance of products from the northern part of the island within its territory. The study of RTV-style materials found in Serra del Palco suggests their presence in the center of the island is due to a communication route through the river valleys of Torto and Platani. These valleys connected the two coasts, making Milena a possible hub for routes leading from the hinterland to the coasts. [Castellana 2002, Gallo 1984]. On the other hand, the site of Mezzebbi, located along the Gallo d'Oro River, contains various materials of western origin, dated between the end of the Eneolithic and the beginning of the Bronze Age [Privitera 1997, 91]. This supports the idea that materials circulated from the west towards the heartland of the island.

6. CONCLUSIONS

Starting from the study of routeways, it is possible to observe the methodical and strategic way prehistoric communities occupied the landscape. Researchers have studied the role of Milena's territory within broader networks in depth. In secondary literature, Milena was known to be a possible hub within an ancient system of routes that connected the Tyrrhenian coast with Agrigento due to Aegean materials in the territory. However, this study attempts to locate the prehistoric route systems' specific pathways, beginning with the superimposition of settlement patterns from the Neolithic period through the Middle Ages. Using an interdisciplinary approach, this study was able to identify and hypothesize prehistoric routeways in the territory of Milena in central Sicily by combining UAV technology, remote sensing, and GIS applications. Considering the presence of hills, mountains, rivers, and valleys, the geomorphological conditions of the landscape allow for only specific natural pathways to be easily traversable. Thus, it is possible to study the ancient movement structures without new material evidence of their existence. This methodological approach is a particularly efficient means of identifying and hypothesizing specific prehistoric pathways, especially about the Bronze Age, across the interior of Sicily. As has been shown, the settlement logic of the hinterland and mountainous areas on the island can sometimes be replicated in other parts of the island. The successful results of this case study establish it as a model for best practices in identifying specific prehistoric routeways. By combining the study of topographic features with technological methods, we aim to apply this approach to other similar contexts to ultimately shed light on this previously unresolved issue. In this way, future research will find new possible Bronze Age routeways from the territory of Milena towards the northern and Eastern coasts of Sicily. During future research, more precise LCP analyses will examine ancient population movements and adaptations to the landscape.

7. ACKNOWLEDGEMENTS

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