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Settlement strategy and paleoenvironmental reconstruction of Menekşe Catağı from chalcolithic period to ancient times in North-western Turkey

Abstract

In this study, the findings obtained from the archaeological and geomorphological research carried out in Menekşe Çatağı settlement, especially in 2023 drillings excavations, are presented and interpreted in a geoarchaeological context. Menekşe Çatağı is located on the northern coast of the Marmara Sea, 12 km west of Tekirdağ province. This settlement was inhabited by a range of cultures extending from the Middle Chalcolithic Period to the Ancient times, and data about these cultures were unearthed through archaeological excavations. This article provides direct and indirect evidence regarding the sedimentological change processes of Menekşe Çatağı settlement, during a wide range of cultural layers. It is necessary to consider the main scope of this study not only as a means of revealing the physical structure of external factors experienced in the past but also as a part of the process of understanding the dimension and variability of the dialectical interaction between the social environment and the physical environment. In this context, the space use, and changes of the inhabitants of Menekşe Çatağı have been mapped in detail. An attempt has been made to define how geological factors affect the area where the settlement is located. By evaluating geomorphological studies and archaeological data, more realistic interpretations were made by revealing the transformations in the settlement strategy and the inhabitant's reactions to this transformation.

Keywords: Menekşe Çatağı, sedimentology, geoarchaeology, Menekşe stream, earthquake

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Introduction

The discourses on the diversity of the relationship network between humans and the built environment gained momentum with the emergence of cultural evolution theories in the 19th century.[1,2] This period marked a significant shift in understanding human interactions with their surroundings, as scholars began to explore how cultural and social factors influence spatial organization.[3–8] The theories of cultural evolution provided a framework for examining these interactions as dynamic processes rather than static phenomena. This complex relationship network has been addressed over a wide range of time, from environmental determinism to social evolution and from social evolution to individual behaviour.[9–12] Such diversity in approaches reflects the multifaceted nature of human-environment interactions. For example, environmental determinism emphasizes the primacy of geography and climate in shaping human societies[13,14] while social evolution highlights the role of societal progress and technological advancements in influencing settlement patterns. These perspectives collectively enrich our understanding of the interplay between natural and cultural factors. A common understanding among all these different views is that the ways people determine, build and even equip their living spaces are shaped by their social, cultural and political characteristics and that the physical environment also affects the shaping of the social environment, and this has been and continues to be discussed a lot. This idea aligns with Lefebvre's[15] concept of the "production of space", where human activities and cultural practices actively transform physical spaces, and these spaces, in turn, influence human behaviour and societal structures. This dialectical relationship underscores the mutual dependency between the social and physical realms. It is a point that needs to be addressed: the change or transformation in the environments where people live is closely related to the social structure and behaviour of communities, and the differentiation in the physical environment also forces this organization to change. This observation highlights a feedback loop, where shifts in the environment - be they natural or anthropogenic - necessitate adaptations in social organization.[16]

In this context, geomorphological studies greatly help us understand the interactions of people with natural environments in the past and the physical factors that shaped their lifestyles. Geomorphological analysis provides essential tools for decoding past human-environment relationships. By studying landforms, soil compositions, and river systems, researchers can infer settlement strategies, resource utilization, and the environmental challenges faced by historical communities.[17] Regardless of the name and definition of the group, community, or society that inhabits an archaeological site, the phenomenon of human perception of space and its relationship with the physical environment is the most basic and distinct relationship network in terms of its existence. The human perception of space reflects a universal aspect of cultural identity and interaction with the environment. However, there is also a deeper dynamic underlying the human-environment relationship. The dialectical equation should be addressed in the mutual interaction of the social environment and the physical environment. The dialectical equation, which expresses the essence of things that contain the principle of movement in the context of change, people affect the physical environment in which they live and are also affected by this physical environment. This dialectical perspective reflects the principles of historical materialism[18] where

the material conditions of existence -shaped by both natural and human factors -drive societal development.[19] Therefore, the human-environment relationship is a product of social structure and cultural dynamics and the interaction between the physical environment and humans.[20]

This interdependence is central to understanding human history, as it reveals how cultural frameworks and environmental conditions co-evolve to create complex socio-ecological systems. In this study, the causalities of the physical environment affecting the spatial distribution of communities using Menekşe Çatağı settlement are tried to be explained in the context of geomorphology and geoarchaeological studies. This settlement is located on the northern shores of the Marmara Sea, approximately 12 km west of Tekirdağ province[21] on an erosion-accumulation surface at 6–11 meters above sea level Figure1. Menekşe Çatağı case study illustrates how specific physical features, such as water sources and geological stability, influence settlement patterns. Analysing such sites helps reconstruct historical landscapes and societal adaptations.[22] This settlement has hosted various cultures in different periods throughout history and has witnessed significant changes or transformations over time. The stream's strategic importance highlights the role of water systems in shaping not only settlement choices but also cultural and settlement pattern activities. Menekşe Stream, which is one of the essential natural elements that determine the settlement strategy and is located near the settlement, is a significant starting point for understanding the spatial use and changes of the study area. In addition, this study attempts to reveal the causality of the change in Menekşe Stream bed by analysing the source parameters of earthquakes that may cause structural displacements in the settlement, fault type and mechanism. By incorporating archaeological and riverbed data, the study provides a comprehensive view of how natural disasters and tectonic activity contribute to landscape and societal changes.

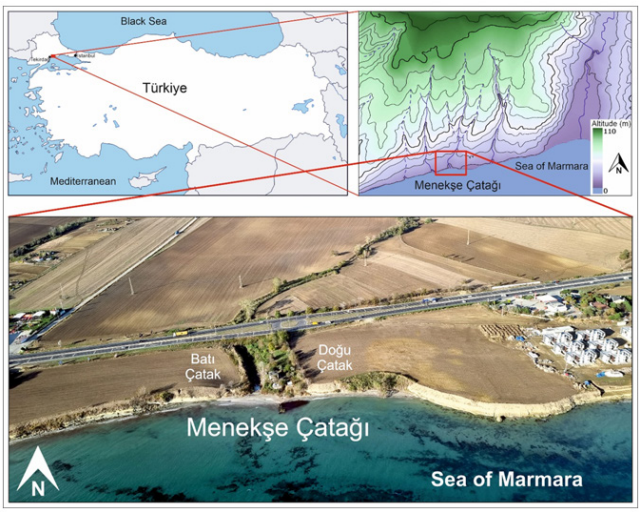

Figure 1 Location and elevation of the settlement.

Materials and methods

The excavation and drilling data from the Doğu Çatağı of this Settlement in 2023 constitute the focus of this study (Figure 1,2). This focus on recent field data enables a more nuanced understanding of the settlement's stratigraphy and paleoenvironmental context, building on the comprehensive dataset from earlier excavations (1994-2007) and the literature review incorporating 2015 findings. Integrating past and present excavation results ensures a multi-temporal approach to interpreting the site's stratigraphic development and settlement dynamics. In the 2023 field studies, the drillings opened in rows at different points were examined in detail regarding the archaeological layer, the reconstruction of the paleoenvironment, and the sediment stacks. The stratigraphic analysis of 37 drillings- including 33 drillings measuring 5x2m, 2 drillings measuring 4x2m and the last drillings measuring 2x2m-provides critical data for reconstructing the environmental and cultural processes that shaped the site (Figure 2). Stratigraphic excavation and sedimentological classification are fundamental in geoarchaeological research, as they help identify human-environment interactions[23] over time. The depths of the drillings vary. The first reason is that the virgin soil or bedrock level, where archaeological material is not detected, is reached just below the surface soil. The second reason is that the primary rock is detected at depths due to the thick accumulation of virgin soil in some sections due to the corrugated surface of the Denişmen Formation. The third reason is that the surface soil and/or the yellowish camel-coloured clayey-sandy units covered by the virgin soil, especially in the D4, D3, E3 and A1 drillings, continue pretty deep (Figure 5). These variations highlight the site's geomorphological complexity. The interplay between natural sedimentation processes and anthropogenic activities, such as agriculture, has created a stratigraphy reflecting human and environmental influences over millennia. Since this clayey-sandy sediment is related to the old stream filling, it was dug deep, and its relationship with the bedrock was tried to be determined and understood. Stream-filling sediments, particularly those linked to paleo-hydrological systems, are valuable indicators of past environmental conditions. Their analysis can reveal changes in watercourse dynamics, sediment transport, and depositional environments.[24] This focus is crucial for understanding the site's settlement strategy and environmental constraints. Four main lines were determined in the stratigraphic section measurements of the drilling excavations in 2023. Starting from the top, the first stack is brown surface soil with heterogeneous and occasionally amorphous broken pottery pieces. This surface soil shows thicknesses between 30 and 60 cm in different sections. Pottery fragments within the topsoil suggest surface disturbances caused by intensive agriculture and previous excavation activities. Such findings underscore the need to interpret surface layers carefully, as they may represent secondary depositions rather than in situ cultural layers. There is a very mixed soil structure due to intensive agriculture. In addition, it is known that during the archaeological excavations between 2001 and 2007 at Menekşe Çatağı, especially in the northern parts, where waste soil was thrown, this filling was 50–60 cm thick. These anthropogenic alterations, including backfilling and agricultural use, complicate the stratigraphic sequence and necessitate cross-referencing with historical excavation records to distinguish original contexts from disturbed ones. The second layer is the virgin soil stack. As mentioned above, it was determined that the Denişmen formation under this stack had different thicknesses due to its corrugated structure. The measured thicknesses of the examined stratigraphic sections vary between 35 and 97 cm for virgin soil. This variability highlights the influence of natural geomorphological processes in shaping the subsurface stratigraphy. The undulating surface of the Denişmen Formation likely reflects fluvial and sedimentary dynamics, which must be accounted for in reconstructing site formation processes.[25] The third layer was detected in very few areas. This clayey-sandy unit, an old stream bed accumulation, was determined to be 61–114 cm thick. Although the stone and sand lines increase in places, its general appearance is a homogeneous stack feature. Streambed accumulations like this provide critical insights into past hydrological conditions and resource availability. Such layers are often associated with settlement proximity to water sources, a common feature in prehistoric and

early historic settlement strategies. The fourth and last layer is the Oligocene–Early Miocene-aged Denişmen formation, which is the bedrock of the area where Menekşe Çatağı is located, and this greenish-yellow sandstone unit. During the excavation works, it was determined that the surface of this formation was looser and could be excavated with a pickaxe. Towards the deeper depths, a rugged sandstone rock became apparent and lost its feature of being excavated by human power. After determining this level, excavation work in the relevant drilling area was terminated. Identifying the Denişmen Formation as the site's bedrock is crucial for stratigraphic analysis. Its properties influence the depositional environment and the practical aspects of excavation, such as the decision to terminate digging when this layer is reached.

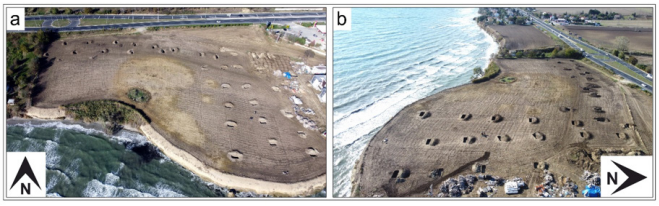

Figure 2 Location of 37 drillings excavated in designated areas from Menekşe Catağı.

Determination of the stack and layer is based on detailed examinations in the fieldwork, a comparison with literature data, and significant changes in the stack, sediment structure, and colour of the accumulations. All these data were compared with published studies within the scope of Menekşe Çatağı archaeological excavations and unpublished 2010 COMU BAP report data; Menekşe Çatağı settlement distribution, differences in land use and paleoenvironment were tried to be determined and interpreted. Combining field observations with existing literature and reports, this integrative approach ensures a robust analytical framework. Data triangulation is essential in archaeological research to validate findings and draw comprehensive conclusions about past human-environment interactions.[26] The study used a multidisciplinary and multilayered approach integrating excavation and drilling techniques to analyse hydrological changes and cultural dynamics. The stratigraphic analysis allowed us to identify distinct river fills and reconstruct historical hydrological patterns, including paleo-river systems. Hydrological features were interpreted using GIS mapping and spatial analysis to relate them to settlement patterns. The findings are based on detailed examination and interpretation of soil and sediment samples, which provided a comprehensive understanding of the environmental and cultural history of the study area (Figure 3).

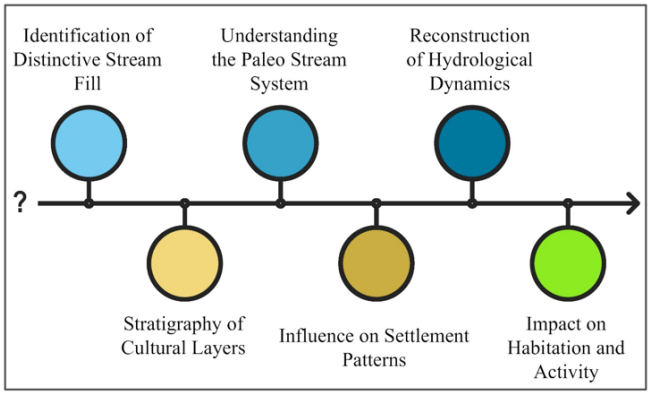

Figure 3 Methodological processes used in the meaning of Menekşe Catağı 2023 drillings.

Stratigraphy and archaeological context of Menekşe Catağı settlement

The settlement is located on the northern shores of the Marmara Sea. This strategic positioning near the Marmara coastline has made it a pivotal location for cultural interactions and settlement throughout history, serving as a crossroads for Anatolian, Aegean, and Balkan cultures. The settlement, resembling a flat mound, is bisected by Menekşe Stream, which has played a crucial role in shaping the site's spatial and cultural history. As a result of the archaeological excavations conducted by the Tekirdağ Museum Directorate between 1994 and 2007, and whose scientific advisor was Dr. Aslı Erim-Özdoğan revealed many aspects of the settlement's cultural history.[27,28] The correspondence author of this article also served as a student and later as a field manager in this team during the relevant period. These long-term investigations illuminated Menekşe Çatağı's multi-layered stratigraphy, emphasizing its role in different cultural phases, such as the Middle Chalcolithic, Early Bronz Age, Early Iron Age and the last cultural phase before complete abandonment is the Ancient time. However, the absence of research after 2007 resulted in a significant gap in understanding its eastern boundaries and environmental dynamics. Renewed excavations in 2015 and 2023 by Dr. Savaş Sarıaltun aimed to fill this gap by determining the settlement's boundaries and tracing the old streambed of Menekşe Stream. Having said that, the 2023 drilling studies conducted at 37 points precisely identified the northern and eastern limits of the settlement (Figure 2, 5).

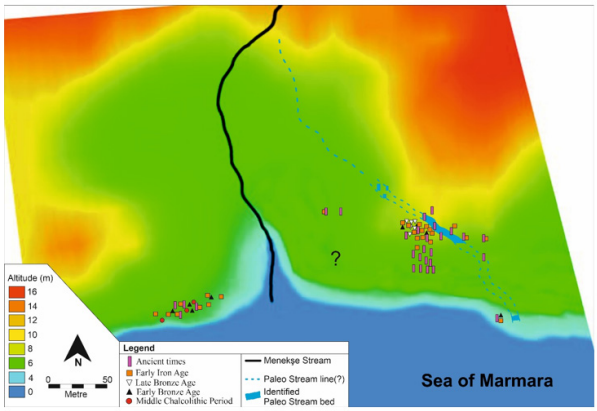

Figure 4 Settlement pattern and land use of Menekşe Catağı from the chalcolithic period to the ancient times and digital elevation model of the study area.

During earlier excavations, the Middle Chalcolithic Period was identified on the Batı Çatak of the settlement.[29] However, no Middle Chalcolithic layers were found on the Doğu Çatak during the 2001–2023 studies (Figure 4). This spatial differentiation underscores the settlement's potential functional and cultural zoning, with the east flank yielding votive offering areas from the Early Iron Age and a sacred structure complex from Ancient times. These findings suggest that distinct ritual and sacred functions dominated the Doğu Çatak during specific cultural phases. Troy I- II pottery is prevalent in the cultural area where the settlement is located. In contrast, Balkan cultural influences, such as Sveti Krilovo-phase pottery and parallels with the Toptepe and Aşağı Pınar Middle Chalcolithic layers are also evident.[30] This duality of cultural influences reflects Menekşe Çatağı's role as an intercultural bridge, blending Anatolian and Balkan traditions. Similar patterns are observed in the Early Iron Age, with Balkan cultural artefacts coexisting alongside red-slipped wares from northwestern Central Anatolia. This synthesis of material culture

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highlights the settlement's integrative role in fostering cross-regional interactions during critical periods of cultural transition.

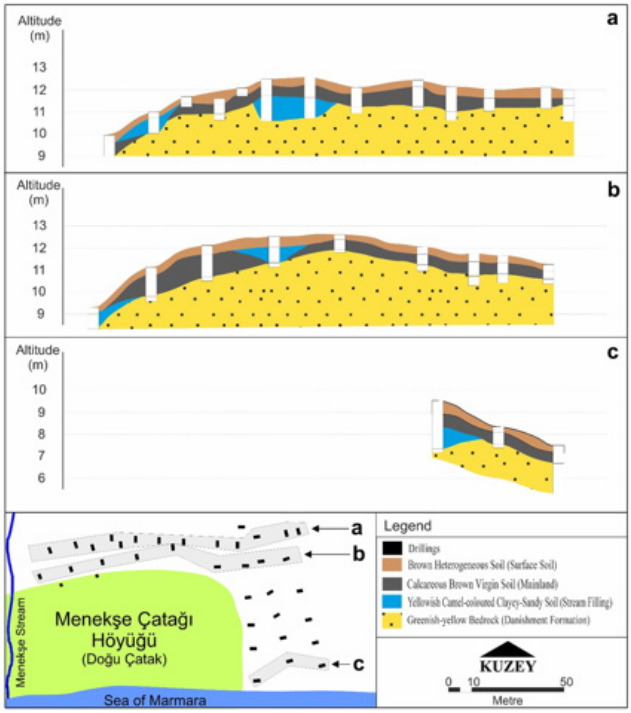

Figure 5 Geomorphological and archaeological cross-section drawings and locations of drillings in designated areas from Menekşe Catağı.

The settlement's significance is particularly evident during the Early Bronze Age (EBA), Late Bronze Age (LBA)/Early Iron Age (EIA), and Ancient times. Excavations between 2000–2007 uncovered cultural layers from these phases in both flanks (Doğu – Batı Çatak) of the settlement. The discovery of offering pits, burial traditions, pottery assemblages, and architectural remains provides substantial horizontal and vertical stratigraphic data, enriching our understanding of the site's diachronic development. These features reflect Menekşe Çatağı's dynamic settlement strategies and evolving spatial organization, particularly in the Doğu Çatağı area. Additionally, sedimentary variations linked to different cultural phases provide crucial environmental and geological insights. Flood traces in the old streambed and slopes of Menekşe Çatağı, axis shifts in architecture of the Ancient times, preserved marine terraces, and earthquake-related phenomena such as landslides and structural collapses underscore the settlement's vulnerability to natural forces. These findings align with geoarchaeological approaches, demonstrating how environmental changes shaped human adaptation and settlement strategies over millennia. The yellowish clayey units overlaying EBA and LBA/EIA cultural layers and geomorphological markers offer vital clues about the site's paleoenvironment. These observations indicate that Menekşe Çatağı experienced significant landscape changes from prehistory to the present. The interplay between environmental dynamics and cultural resilience at the settlement exemplifies the adaptability of ancient communities to fluctuating conditions. Contributing to the broader discourse on human-environment interactions.

Physical environment of Menekşe Çatağı settlement and its vicinity

In the area where the settlement is located, the sandstone unit belonging to the Oligocene-Early Miocene Danişmen Formation[31]is spread. This greenish-yellow sandstone, formed in a delta system, extends along the Marmara Sea coastline between Tekirdağ and Istanbul provinces and marks a critical transition from a marine to a terrestrial environment by the end of the Early Miocene Period.[32] The Danişmen Formation was subsequently covered by Late Miocene-Pliocene units; however, due to erosion and non-deposition.[33] Pliocene units are absent in the specific area of Menekşe Çatağı settlement. Excavations carried out between 2015 and 2023 revealed a dark brown, loose-textured primary soil layer unconformably overlying the Danişmen Formation. This early Holocene soil, varying in thickness between 40 and 100 cm, reflects the geomorphological influence of the Danişmen Formation's topography and surface erosion. Its composition, including sandstone and gravel particles, indicates fluvial and marine regression processes shaping the landscape during the early Holocene. Despite its geological significance, no archaeological material has been identified in this layer. The first cultural phase established on this primary brown soil was the Middle Bronze Age, as identified in the Batı Çatak of this settlement. This settlement phase highlights the gradual occupation of the area following significant landscape changes in the early Holocene, consistent with patterns observed in other Marmara region sites. The settlement's abandonment corresponds to the Hellenistic Period, marking the end of its occupation within the cultural phases of the Ancient times. Geomorphological studies and excavation findings indicate that the pre-Ancient times topography of Menekşe Çatağı differed significantly from its present form. Particularly lateral faulting mechanisms, caused significant shifts in Menekşe Stream bed, leading to ruptures and subsequent settlement redistribution during different periods. These riverbed changes underline the impact of geological dynamics on human settlement strategies. Following these changes, the distribution of settlement areas evolved, reflecting adaptive responses to environmental disruptions. These dynamic underscores the resilience of ancient communities in navigating and reorganizing their living spaces amidst changing landscapes. The findings from Menekşe Çatağı reveal the profound interplay between geological processes and cultural evolution, offering critical insights into the settlement's history from the Middle Chalcolithic Period to the Ancient times.

Interpretation and evaluation of archaeological and geomorphological results on the reconstruction of the paleoenvironment

As a result of the excavation and drilling works and sediment examinations in 2023, a distinctly yellowish camel-coloured clayey-sandy stream fill was detected in the D4, D3, E3 and A1 drillings. This distinctive sediment layer provides critical evidence for reconstructing the hydrological dynamics of this site. The clayey-sandy stream fill detected in a thin layer in the E3 drilling indicates that the western border of the old stream has been reached. As mentioned above, no stream fills were encountered in the west and east of the drillings. This absence suggests that the stream's activity was localized and that its hydrological influence diminished further from its core course. The clayey-sandy stream fill levels detected in the D8 and E6 drillings are related to the current eastern side fills of Menekşe Stream. The stream fill in the D4 drilling is 114 cm, and in the D3 drilling is 94 cm (Figure 5). Due to the thick stream fill and sediment characteristics in the D4 drilling, passing the old stream thalweg line through the D4 drilling would be more appropriate. The varying thickness of these fills reflects the natural variability of sediment deposition in fluvial systems, often shaped by factors such as rainfall intensity, water

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flow, and seasonal changes. However, although the stream fill is 73 cm thick in the E3 drilling since the stream fill was not detected in the drillings to the east and west, it is understood that the old stream thalweg line passes through the area where the E3 drilling is located. However, if the distance between the D4 and D3 drillings just to the north is 18 m, it is also possible that there are two channels in the section where the D4 and D3 drillings are located. The stream may have flowed in one of these channels at different time intervals, and it is also possible that both channels may have been used depending on the rainfall and water flow. This braided channel structure is a typical situation in river systems and is frequently seen in sections where the slope decreases. In addition, when the D4-D3 and E2 drillings in the north are evaluated together, it is understood that the old stream bed has formed a slight bend in this area; this situation is also compatible with the old stream bed identified in Menekşe Çatağı excavations and the current Menekşe Stream's slightly meandering, braided bed type.

The yellowish camel-coloured clayey-sandy shallow stream fill identified, especially in trenches 46M and 46O in the 2015 excavation works, is also related to the floods affecting the eastern slopes of the old stream bed. However, although the stream fills in trenches 44M, 46M, and 46O partially cover the prehistoric layers, no evidence was found that the stream fill detected in drillings D4-D3 and E3 covered the cultural layers. Therefore, it was revealed in the 2023 drilling excavations that the cultural east of Menekşe Çatağı ended in the north of trench 41K. The old stream fill was also detected in drilling A1, which was opened at the southernmost part of the settlement area, right next to the seashore. The old stream filling in this area was 99 cm thick, and its lowest level was found to flow just above the Danişmen Formation. Considering the shoreline and sea level, it was understood that the old stream bed did not erode the Danişmen Formation, and therefore, this bed was not used by the old stream for a very long time. When all these are evaluated together, it can be suggested that the old Menekşe Stream was a young-formed stream and/or its erosive force was not as high as the current stream flow. Likewise, although the current bed of Menekşe Stream reaches the sea by eroding the Danişmen Formation, the same is not the case for the old stream bed. The presence of a stream surrounding the area where LBA/EIA cultural fillings are spread in Menekşe Çatağı was revealed during excavations. This finding underscores the role of fluvial systems in shaping prehistoric and ancient settlements, particularly in regions where hydrological dynamics directly influence settlement placement and stratigraphy. While beneficial for water supply and agriculture, streams also pose challenges, including periodic flooding that can disrupt cultural deposits and settlement activity. Yellowish sandy fillings formed due to stream overflows immediately south and west of this stream were identified in detail during excavations. Such sedimentary deposits often reflect episodic environmental events, including increased discharge or seasonal floods. Their presence suggests that the stream's overflow periodically influenced the settlement's surrounding area, creating depositional layers that marked past hydrological conditions. However, it was determined because of the studies that clayey-sandy units covered Early Bronze Age and Early Iron Age cultural fillings due to an old stream-based flood in 2015 excavations. In 2023 drilling excavations, the clayey-sandy units in question were identified in detail both in the north and eastern outer part of the settlement. This stratigraphic relationship demonstrates the disruptive potential of fluvial activity on cultural layers. The burial of EBA and EIA fillings by flood-derived sediments aligns with findings from other archaeological sites, where riverine systems play dual roles in supporting and challenging human habitation (Figure 6).

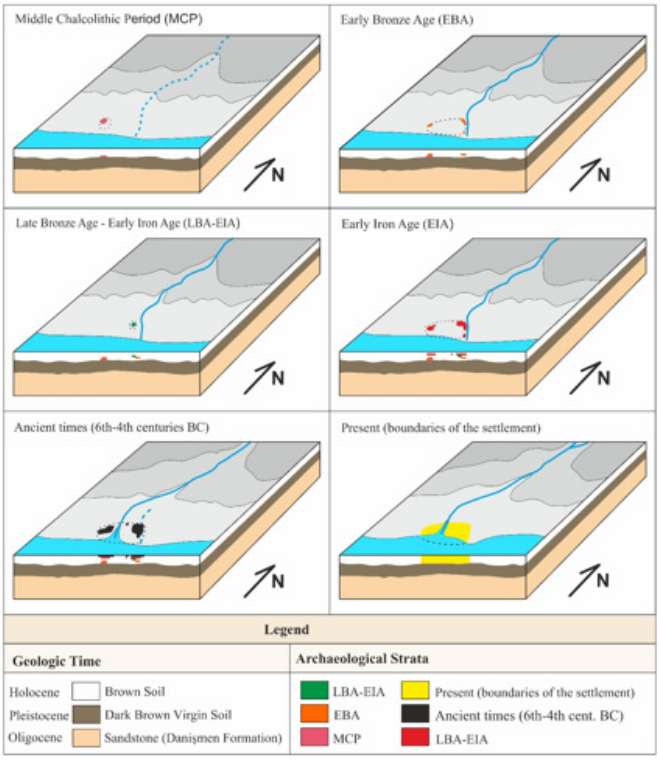

Figure 6 Changes in Menekşe Catağı settlement pattern from the first settlement process to the present and its relationship with Menekşe stream.

Therefore, it was understood that the cultural fillings were spread unconformably on the Early Holocene brown mainland on the Danişmen Formation, which is the bedrock of Menekşe Çatağı settlement. This unconformable relationship points to significant temporal and environmental shifts between the formation of the Danişmen Formation and subsequent human activity. It was also understood that the stream bed partially dried up and was filled towards the end of the Early Iron Age. In the archaeological excavations carried out in Menekşe Çatağı, it was determined that the old stream bed in question was approximately 6 meters wide and 1.10 meters deep. Another evidence showing that the old stream flowed or formed a watery environment during the Late Bronze Age to Early Iron Age transition period is that archaeological fillings belonging to these periods were not detected in the stream bed. However, just before the beginning of Ancient times, probably between the 7th and 6th centuries BC, the area in question began to dry due to the change in the old stream bed, and various types of ancient architectural remains, votive pits, pottery, etc. archaeological findings were detected both in the excavation works and in the geomorphological section examinations in the upper levels of the areas where the stream fill passed. This phase reflects an environmental transition coinciding with a cultural and spatial reorganization, allowing new landscape uses for practical and ceremonial purposes.

Prehistoric pottery pieces were detected scattered under and inside the yellowish camel-coloured clayey-sandy stream fill detected in the eastern part of the settlement. Especially in the northwestern part of Trench 44M, right on the edge of the old stream bed, Buckel pieces, typical of the Early Iron Age from Balkan cultures, and a whole vessel and deer antlers dated to the same period were found in situ. These discoveries highlight the site's cultural connections to the Balkans and

its role as a contact zone between various regional traditions. It was determined during the studies that the yellowish buff-coloured clayey-sandy sediment, which was the bed flood of the old stream, partially dragged these findings and then covered them. In addition, animal bone fragments covered with calcite and lime were found on the edges of the old streambed. These findings indicate that the archaeological material next to the old stream bed remained in a watery environment for at least a specific period. Therefore, during the Late Bronze Age to Early Iron Age transition period, the eastern part of the settlement, especially the stream bed area, was exposed to floods originating from the stream one or more times and partially destroyed the cultural fillings. Such preservation conditions ensured that the materials were exposed to an aqueous environment for an extended period, providing valuable contexts for archaeological interpretation.

Anatolia and Thrace's geography has been exposed to earthquakes of different natures and effects throughout history,[34-37] especially in ancient cities such as Nicomedia, Smyrna, and Troy. Although some of these cities returned to their former glorious days quickly, most were either abandoned or never returned to their former glorious days. Menekşe Çatağı building complex from Ancient times, which was used in different periods and repeatedly with additions and repairs, is located in the southern part of the settlement's present-day appearance. However, while we are on the subject, we want to state the following. Due to rock breakage due to the cliff formation on the southern shore of Menekşe Çatağı, the actual southern part of the settlement is currently under the waters of the Marmara Sea. Getting back to the subject, it has been understood that the Ancient times building complex was built in the mid-6th century BC and that it was repaired and used several times during the 5th-4th centuries BC. Archaeological data shows that this building complex was affected by earthquakes at least twice and was rebuilt and used again. As can be understood from the slips and/or collapses on the walls of Menekşe Çatağı building complex from Ancient times, severe damage occurred to this structure as a result of lateral-slip faulting.

However, in the 4th century BC. This building complex, severely damaged by an earthquake that probably occurred in the late 4th century, became unusable and was subsequently abandoned completely and never used again. Although the old stream bed that borders the LBA/EIA settlement from the north and east needs to be confirmed with more comprehensive geophysical earthquake studies, it has been documented that the old bed of Menekşe Çatağı, which currently flows approximately 100 meters to the west, flows from the east of the settlement, both in the 2001-2007 archaeological excavations and in the 2015 and 2023 excavations and geomorphological studies. In addition, the fact that Menekşe Çatağı bed makes a sharp turn approximately 100 meters to the west, just 200 meters north of the settlement, is another hydrographic data supporting this claim (Figure 7). In this area, Menekşe Çatağı turns south at an angle of approximately 90 degrees to the right. This sharp turn is related to the earthquake caused by a local fault with a left lateral strike. The Gavurayama Stream to the west and Derince Stream and Ağılovası Stream to the east, which were affected by the exact mechanism as the channel change of Menekşe Stream because of the strike-slip fault mechanism, also shifted their channels to the west by an average of 80-90 m. The most important reason why no channel change was detected in Kurusıval Stream to the west of Menekşe Stream is related to the fact that this stream is a young seasonal stream.

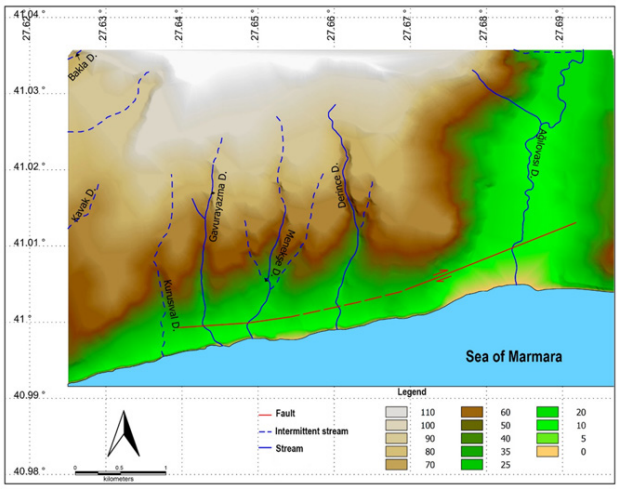

Figure 7 The location of the right-lateral "Menekşe fault" located in the north of Menekşe catağı and the change of stream beds.

Conclusion

Geomorphological and geoarchaeological studies in Menekşe Çatağı have provided an essential source of information for understanding the paleoenvironment of the region in prehistory and Ancient times. Cultural fillings spread on the Early Holocene brown mainland represent the process from the Middle Chalcolithic Age cultural phase to the Hellenistic Period. Geomorphological studies and geoarchaeological interpretations have revealed how the topography of the settlement has changed over time. The change of channel of Menekşe Stream under the effect of the strike-slip fault mechanism is a critical geological event in the study area and a phenomenon affecting the settlement strategy, spatial use, and distribution. The excavations and sedimentological section studies have revealed the presence of stream fillings in the study area, the spreading process and the role of these fillings in the settlement process more clearly. Although we do not have absolute dating data for the earthquake, it is suggested that the 90-degree offset in the streambed occurred before the Ancient times cultural phase and after the EIA in the 7th-6th centuries BC. In addition, based on the apparent earthquake traces in the architectural remains of the Hellenistic Period, we can claim that the "*Menekşe Fault*", which has a lateral slip mechanism, remained active in the 4th century BC and later. The excavations, drillings, and geomorphological studies in Menekşe Çatağı have helped us to understand better the boundaries of the settlement, the relationship between the physical environment and the social environment, and the role of geological factors in the history of the settlement. For this reason, the excavations and geomorphological studies of this site have become an essential source of information for understanding the history and natural environment of the region.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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