



Arařtırma Makalesi / Research Article


THE HAYAT CAVE KARST SYSTEM (SAMSUN, TURKEY)

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ABSTRACT

In this study, Hayat Cave karst system was investigated. The study area is located within the borders of Bařaran village of Bafra district in Samsun province. The system has original shapes belonging to surface and depth karst. The aim of the study is to investigate the ecological, morphological and speleological features of the Hayat Cave karst system which has not been subject of any scientific research up to now. The study is mainly based on field observations and measurements. The knowledge obtained from the area and literature was processed in Geographical Information Systems and they were converted into visual materials. The region has a humid and temperate climate suitable for karstification. The bedrock is generally composed of volcano-sedimentary rocks. However, limestones suitable for karstification are encountered in some places as around of Bařaran village. Brown forest soils are widespread in the area. Flat and slightly sloping lands were generally opened to agriculture in the region. In high sloping areas, wide-leaved forests consisting of species such as beech, hornbeam, chestnut and oak dominate the view. In the area, there are wolf, fox, jackal, marten, hedgehog, squirrel and roe deer as wild animals. In addition, you can see flies, spider and bat in the caves. Hayat Cave karst system starts with a fluvio-karstic depression which is in the east of Bařaran village. Kavaklıgöl Creek which drains the water of the system goes into underground from the swallow holes at the north end of depression. The stream has respectively created two caves while flowing into underground. The Bařaran Cave above is dry whereas the Hayat Cave below is active. The creek pours in the Hayat Cave as two little waterfalls, and flows 35 m along the main gallery and then sinks in a swallow hole and disappears. Therefore, the entrance side of the cave is dry. However, the mud levels, the pebbles and blocks in the bed show that the stream empties from the mouth of the cave into the valley during the floods. Inside the caves there are speleothems with high visual appeal. If the caves are opened to tourism, they can contribute to the development and diversification of local tourism.

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1. INTRODUCTION

In this study, the Hayat Cave Karst System was examined. The study area is located in the Middle Black Sea part of the Black Sea region, and within the borders of Bařaran village of Bafra district of Samsun province (Figure 1). The system contains original shapes belong to

surface and depth karst such as karren, doline, cave, swallow hole, stalactite, stalagmite etc. The aim of the study is to examine the ecological, morphological and speleological features of the Hayat Cave Karst System with a holistic view.

Karstic rocks cover a very large area on the earth. Except for areas covered with glaciers, approximately 1/5 of the world's land (Ford and Williams, 2007), and 2/5 of Turkey's land are covered with karstic rocks (Nazik and Tuncer, 2010). In contrast the proportional excess in Turkey, distribution of karstic rocks in

the Black Sea region which also contains the study area is relatively limited. However, the mild and rainy climate of the region supported the development of karstic shapes in areas where suitable rocks were found (Uzun, 2004a, b).

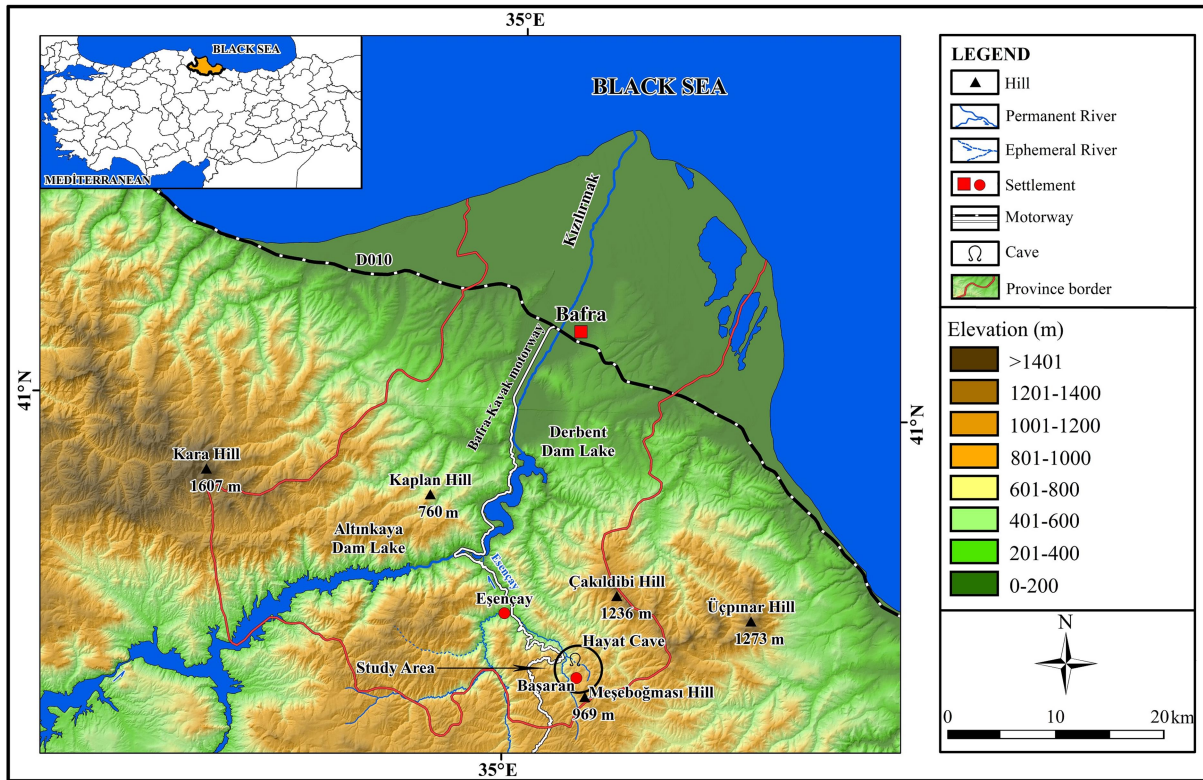


Figure 1: Location map of the study area.

The Hayat Cave karst system investigated in this study was created by the Kavaklıgöl Creek which is one of the tributaries of the Eşençay located in the lower catchment of the Kızılırmak River. The stream starts from a fluvo-carstic depression in the east of the Başaran village and goes underground from the swallow holes on the northern edge of the depression (Figure 2). Underground waters

have formed two caves respectively on this area. The upper one of these is "the Başaran Cave", and the lower one is "The Hayat Cave". The Başaran Cave is located in the vadose zone, and it's dry. The Hayat Cave is active, and the Kavaklıgöl Creek flows along the main gallery of the cave about 35 m. There are some attractive speleothems for tourism in the both caves.

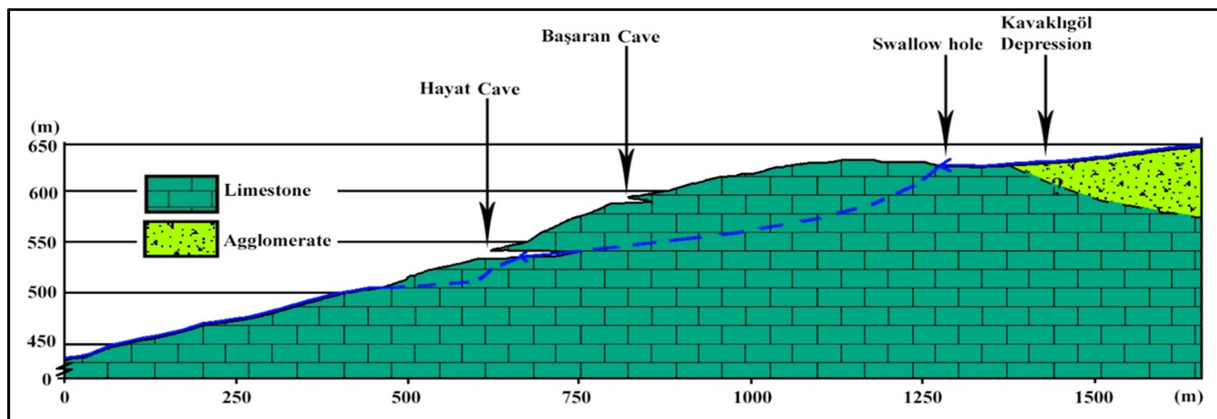


Figure 2: Longitudinal section of the Hayat Cave karst system.

Caves have been used for various purposes such as purification, shelter and storage since ancient times (Gillieson, 1998; Uzun, 1995b). Today, their use for tourism purposes has increased. However, the excessive use of some caves causes serious damage. A four-factor arrangement consisting of *scientific research*, *art*, *technology* and *management* is needed to prevent such negativities and to benefit from caves in a sustainable way (Cigna and Burri, 2000; Vuković and Antić, 2019). Some authors suggest that scientific research should be done first of these factors (Cigna, 2011; Cigna and Burri, 2000; Vuković and Antić, 2019). For this reason, the Karst system of Hayat Cave, which was not subject to a scientific research before, has been studied in a multifaceted way in this study. However, some paper refer to the existence of the Hayat Cave (Özkök, 2019; Samsun Provincial Directorate of Culture and Tourism, 2020), but the Bařaran Cave and other elements of the system are not included.

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2. METHODS

This study was prepared in three stages. The relevant literature was first examined, and then area studies were performed. During the area studies, the locations of the caves were determined, and the environmental characteristics were investigated. Later, the metric, morphological, ecological and speleological features of the system were examined. In this context, in-cave measurements were made, photographs were taken and mapping was done.

The information collected from the fields and the literature was processed using Geographic

Information Systems (GIS) during the office studies. 1 / 25.000 and 1 / 100.000 scale topography and geology maps were used to create a base in GIS analysis. In the production of the Digital Elevation Model map (DEM) of the cave area, ASTER satellite images with a terrestrial resolution of 15 m were used. In the determination of the climate characteristics of the area, Bafra Meteorology station data was used. The profile and path lengths used in the study were calculated on Google Earth Pro.

3. FINDINGS

3.1. Physical Settings of the Study Area

The Hayat Cave karst system is located within the borders of the Bařaran village in Bafra district of Samsun province. The Bařaran village is located on the lower catchment of the Kızılırmak River, and on the sea-facing slope of the Black Sea coastal mountain ranges. The distance of the village from the city of Bafra is 50 km, and the distance from

the city of Samsun is 102 km. TThe village is accessed by a 3 km stabilized road separating from the 47th kilometer of the Bafra - Kavak road.

The Black Sea coastal mountains became land before Neogene and a river network was established depending on the primary slope. In parallel the orogenic development of the region, the research area continued to rise. On the other hand, during the tectonic calm

periods, wide erosion surfaces and erosion steps were formed in the area (Öner, 1990; Uzun, 1995a). In the periods when the rise was accelerated, streams deeply cut their beds, and the parts of old erosion surfaces gained plateau appearance (Akkan, 1970), (Figure 3).

The coastal mountains including the research area, still has been continuing to rise. In a study, it has been determined that the long-term uplift rate of 0.28 ± 0.07 m/ka in the last 545 ka (Berndt et al., 2018).

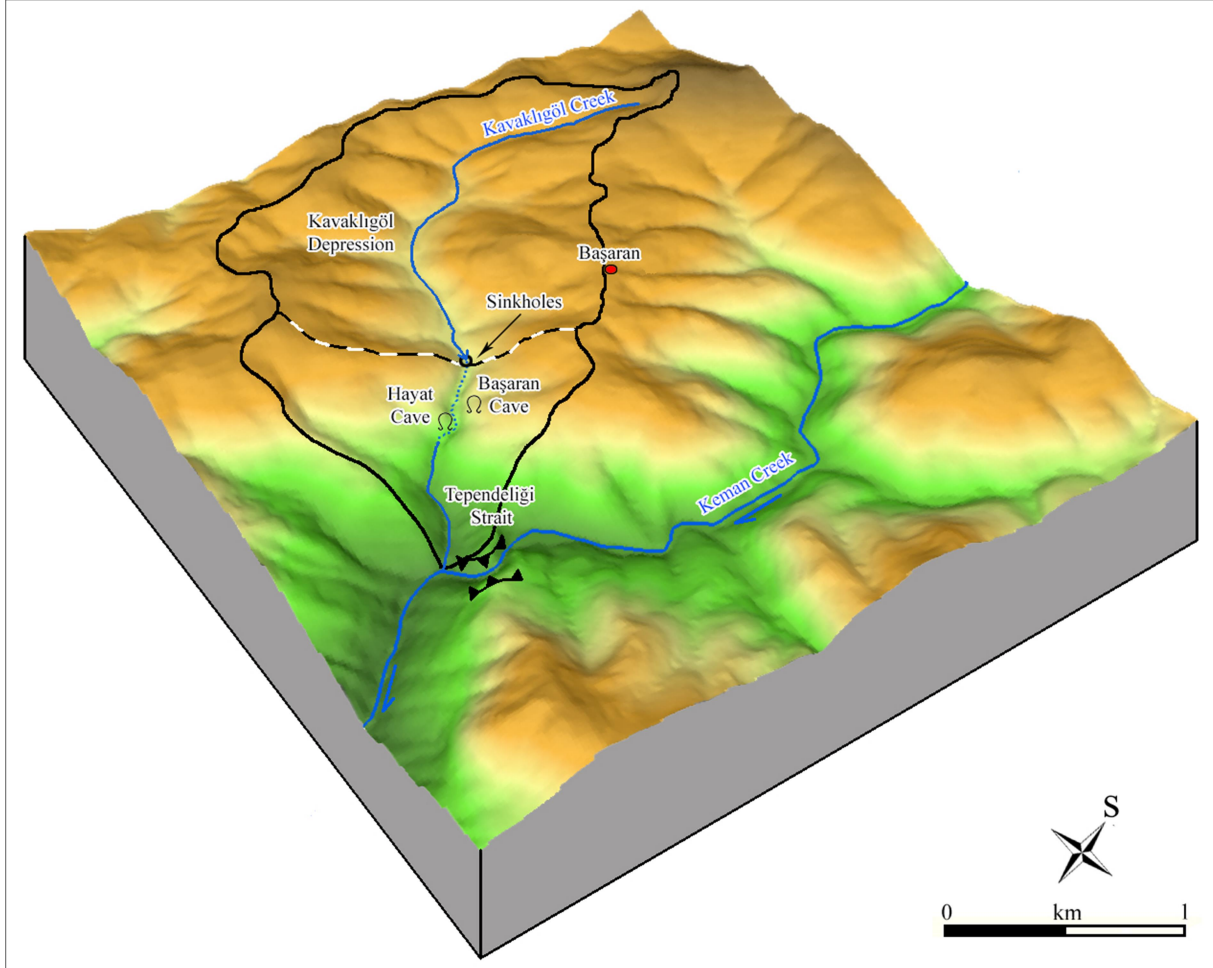


Figure 3: Blockdiagram of the study area and its close surroundings.

Volcano-sedimentary rocks are common around Başaran village (Figure 4; Photo 1). In the sections where these Upper Cretaceous and Eocene aged units were stripped by erosion, Upper Jurassic - Lower Cretaceous limestones belonging to the basement come to surface (Photo 2). In the area, these platform type limestones observed in fragments was named as İnaltı Formation (Ketin and Gümüş, 1963). İnaltı limestones surfaced in the research area have a gray colored massive appearance with abundant fractures. Therefore, surface waters easily go underground and support the development of the depth karst.

In the study area, the humid and temperate climate of the Black Sea coastal zone prevails. According to the data of Bafra Meteorology Station (103 m), the average annual temperature is 13.9 °C, and the annual average rainfall is 715.9 mm (Table 1, Figure 5). According to the Thornthwaite climate classification, the area has a semi-humid and mesothermal climate similar to, ocean conditions, represented by the symbols of C2B1sb4 (Yılmaz, 2007). The study area is located approximately 500 m above the Bafra Meteorological Station. For this reason, the average temperature in the area falls below 12 °C, and the annual amount of precipitation rises above 900 mm. Rainfall usually falls in the form of rain. However, effective snowfalls

are observed in winter season. Rain and melting snow waters especially support the development of underground karst in the area. Kavaklıgöl creek drains the waters of the Hayat Cave karst system. We do not have any observation data with the flow rate and regime

of the creek. However, it is understood that it has the characteristic of overflowing from the basalt blocks and mud levels carried to Hayat Cave from the volcanic land in the source area.

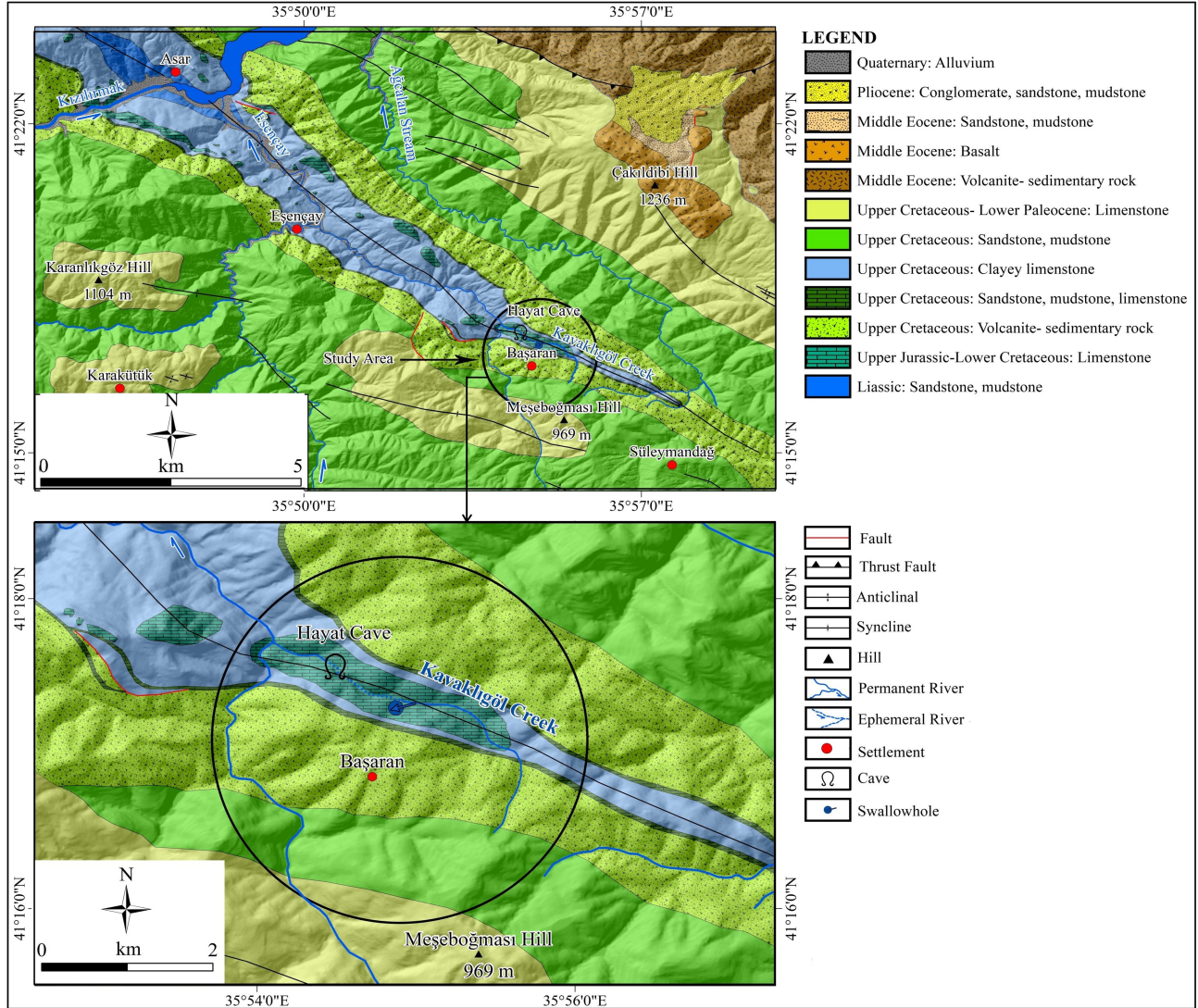


Figure 4: Geology map of the Başaran village and its close surroundings (prepared using MTA Sinop F35b3, F35b4 geological maps).



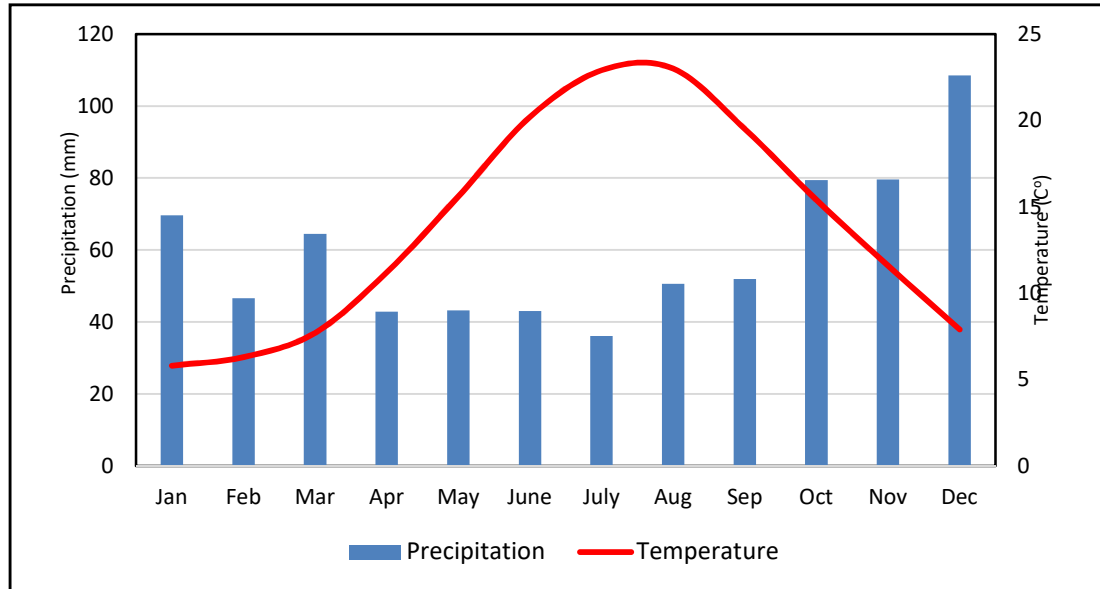
Photo 1: A view from the Upper Cretaceous agglomerates near Başaran village.



Photo 2: Inalti limestones that support karstification in the region, and splitkarren developing on it.

Table 1: Average precipitation and temperature values of Bafrı Meteorology Station (1963-2018), (TSMS, 2019).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Mean Temp. (°C)	5,8	6,3	7,7	11,2	15,6	20,2	22,9	23,0	19,5	15,4	11,6	7,9	13,9
Mean Precip. (mm)	69,6	46,6	64,5	42,9	43,2	43,0	36,1	50,6	51,9	79,4	79,6	108,5	715,9

**Figure 5:** Annual average temperature and precipitation graph of Bafrı Meteorology Station.

The research area is located in the Öksin sub-region of the Euro-Siberian Forest region. However, in low-slope areas close to villages, forests have generally been turned into agricultural land. However, in the Kavaklıgöl Stream basin that forms the caves, there is a lush green forest cover except for narrow openings. The main elements of this forest are beech (*Fagus orientalis*), hornbeam (*Carpinus betulus*), linden (*Tilia rubra*), chestnut (*Castanea sativa*), maple (*Acer campestre*) and oak (*Quercus sp.*), (Photo 3). In addition, some elements such as alder (*Alnus sp.*), elm (*Ulmus sp.*), ashen (*Fraxinus sp.*), plane tree (*Platanus orientalis*) and aspen (*Populus tremula*) are also found in the forest. In areas where trees are sparse, some shrubs and herbaceous species such as medlar (*Mespilus germanica*), hazelnut (*Corylus sp.*), privet (*Ligustrum vulgare*), hawthorn (*Crataegus sp.*), rosehip (*Rosa canina*), blackberry (*Rubus sp.*), fern (*Pteridium sp.*), nettle (*Urtica sp.*) and elderberry (*Sambucus sp.*) are also seen. The research area is also rich in wild animal diversity. Wild species in the region include

weasel (*Mustela nivalis*), hedgehog (*Erinaceus concolor*), mole (*Talpa levantis*), turtle (*Testudo graeca*), rabbit (*Lepus europaeus*), squirrel (*Sciurus anomalus*), wolf (*Canis lupus*), fox (*Vulpes vulpes*), coyote (*Canis aureus*), marten (*Martes sp.*), yew (*Meles meles*), wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*) can be counted primarily. In addition, long-winged bat (*Miniopterus schreibersii*) and horseshoe nosed bat (*Rhinolophus sp.*) and species such as spiders and snails are found inside the caves (Photo 4).

Brown forest soils are common in the study area. In places where the slope degree decreases, the soil thickness sometimes exceeds 1 m. Over the soil, there is an organic layer formed by the decay of various organic materials, primarily tree branches and leaves. Melting snow and rain waters are enriched with acid while passing through this organic material and soil. These waters reaching the bedrock dissolve limestone and support the development of karstic shapes.



Photo 3: A view from the beech forests in the area where the caves are located.

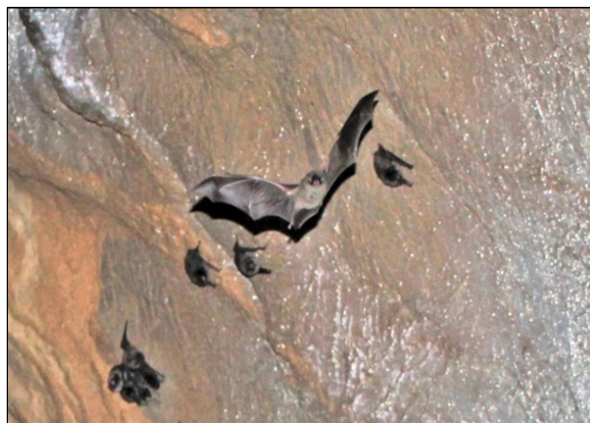


Photo 4: Long-winged bat living in the Hayat Cave

3.2. Karstification and Karst Shapes

Erosion processes became dominant for shaping the region after the Black Sea coastal mountains raised over the sea. For that reason, volcano-sedimentary rocks covered large areas in the region have started to be eroded and the Upper Jurassic-Lower Cretaceous aged limestones were exposed in some places. One of the limited areas where limestones can be seen on the surface is the surroundings of Bařaran village. Thus, suitable climatic conditions were met with karstic rocks, and the Karst system of Hayat Cave has occurred.

3.2.1. Kavaklıgöl Depression

The Hayat Cave Karst system was shaped by Kavaklıgöl Creek. The creek springs from the southern slopes of the fluviokarstic depression,

which it named in the spring area (Figure 3). This depression was mostly opened in the Upper Cretaceous volcano-sedimentary rocks. However, İnalıtı limestones outcropped on the northern edge of the depression, and Kavaklıgöl Creek goes underground through the cracks in this unit (Photo 5). For this reason, it was disconnected from the surface with external drainage.

The length of the Kavaklıgöl depression in the SE-NW direction is 2.5 km and its width in the SW-NE direction is 1.2 km. The stream flows in a "V" shaped valley in its source area. In the part where the swallow holes are located, the valley floor expands and exceeds 100 m. The slopes of the depression are mostly covered by forests, but there are also partly deforested areas at the bottom of depression (Photo 6).

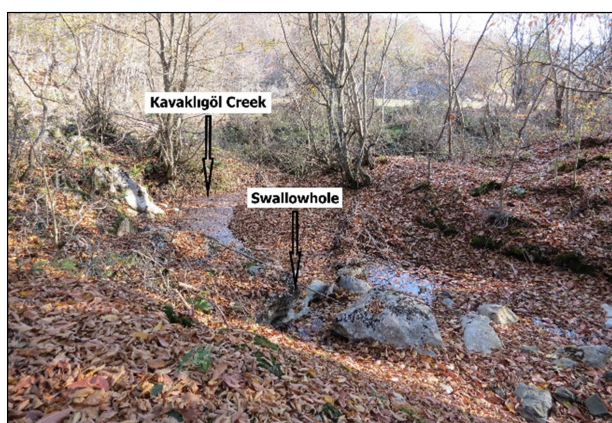


Photo 5: The swallow holes where Kavaklıgöl Creek goes into underground.



Photo 6: The Kavaklıgöl depression and one of the deforested areas in the valley floor.

3.2.2. Kavaklıgöl Creek Dry Valley

The Kavaklıgöl Creek flows underground about 600 m between the swallow holes and the entrance of the Hayat Cave. For this reason,

this part of the valley is dry (Photo 7). But the waters collected from the slopes into the valley in heavy rains cause temporary flow. On the other hand, various karren forms have

occurs on the rocks where the soil stripped along the dry valley (Photo 8). The Kavaklıgöl Creek has formed two caves respectively during the underground flow. The above one is called the Bařaran Cave (Photo 9) and the below one is called the Hayat Cave. The

entrance of the Hayat Cave has collapsed and the valley floor on it turned into a hanging valley (Photo 10). The waters collected in the valley in rainy weather pour from the cave facade and form a small waterfall.

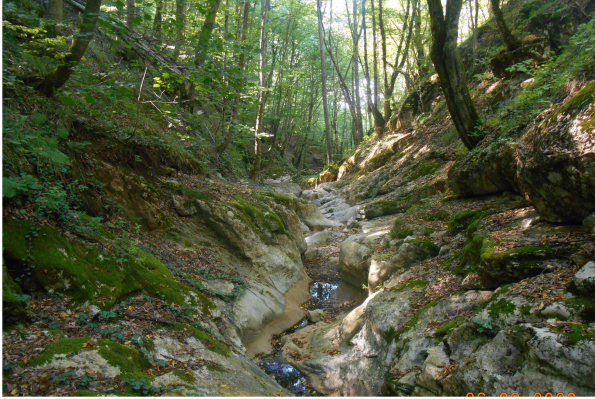


Photo 7: The dry valley of the Kavaklıgöl Creek between swallow holes and the Hayat Cave.



Photo 8: Some rinnenkarrens developed on limestone blocks stripped from the soil cover.



Photo 9: Entrance of the Bařaran Cave.

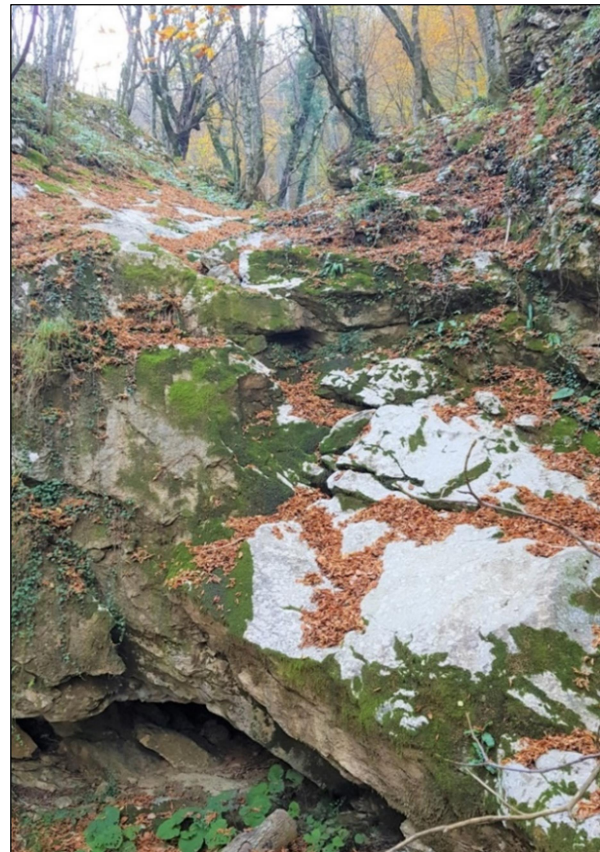


Photo 10: The entrance of the Hayat Cave and the hanging valley above it.

3.2.3. The Bařaran Cave

Bařaran Cave started to form in a water-saturated zone during periods when the local base level is high. When the Kavaklıgöl Creek

was deepening its bed, both the local base level lowered, and the entrance of the cave opened. For that reason, the cave remained in the vadose zone and dried completely (Figure 2). Bařaran Cave is a passive cave developed

horizontally. The entrance to the cave is located on the left bank of the stream and 15 m above the valley floor. The cave has two entrances. Its main entrance is 2.35 m width, and 2.10 m high. The cave entrance is 591 m asl, and its coordinates are 41°17.417°N and 35°54.561°E. The cave has 22 m long main gallery and 5 little chambers developed

depending on the crack systems (Figure 6). The height of the main gallery varies between 1.7 m and 3.5 m (Photo 11). The Bařaran cave is not rich in speleothem formations. But, young stalactites, flowstones, moonmilk shapes and saw-tooth draperies inside the cave are found (Photo 12; 13; 14).

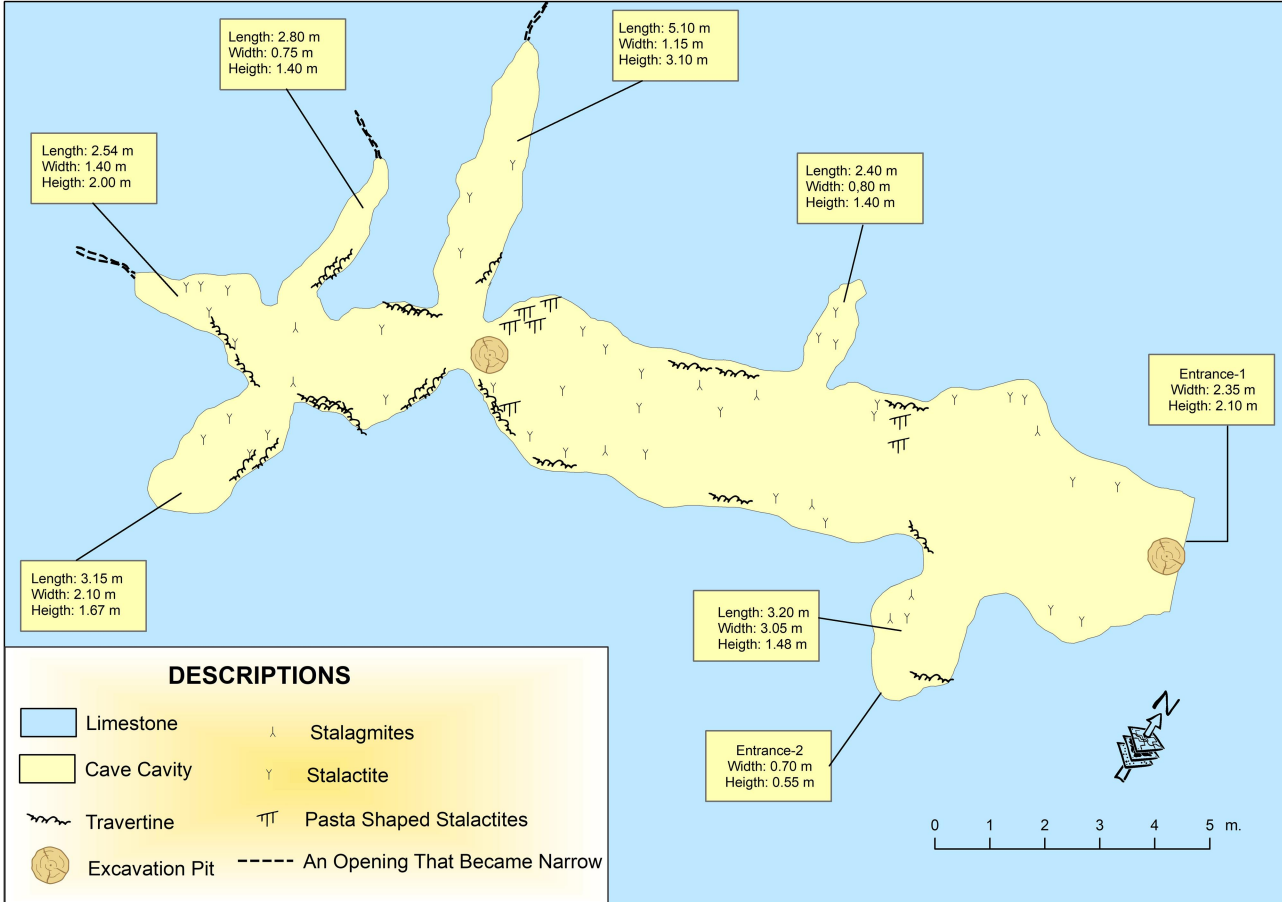


Figure 6: Plan of the Bařaran Cave (Cave Plan was drawn by Faruk AYLAR).



Photo 11: The inside view of the entrance of the Bařaran Cave and an illicit digging area inside.



Photo 12: The young stalactites in the Bařaran cave and the pasta shaped stalactites with broken ends.

Basaran Cave is short in length and its entrance is wide. For this reason, the air of the cave is affected by external atmospheric conditions. As a matter of fact, while the

temperature outside the cave was 14.0 ° C and humidity 80.2% at the end of the main gallery, the temperature was 13.8 ° C and the humidity was measured as 80.6% with Trotec T210

thermo-hygrometer. Accordingly, it can be said that there is a slight difference in temperature and humidity between the outside and inside of the cave. Living species such as flies and spiders, especially bats, were found in the cave. There are traces of an ancient settlement about 1 km west of this cave. For that reason,



Photo 13: Flowstone and curtain shapes in the main hall.

3.2.4. The Hayat Cave

The Hayat Cave is located in the valley of the Kavaklıgöl Creek. It is part of the same system as the Bařaran Cave (Figure 5). It is developed in a horizontal direction and is an active cave. The coordinates of the cave entrance were measured as 41°17.483N and 35°54.492E. Its height above the sea level is 532 m. The main gallery of the cave is shaped according to the crack systems and looks like the letter "L" (Figure 7). Its total length is 198 m. There are two important entrances of the Hayat Cave close to each. Entrance number 1 is located under the hanging valley. The facade of the cave collapsed through a crack and entrance number 1 was opened (Photo 10). In addition, two small windows were opened (Photo 15). Blocks accumulated into the valley as a result of collapse made it difficult to access the cave. Therefore, in case of opening the cave to tourism, road arrangement works will be needed. Entrance number 2 is located on the right bank of the valley and 6 m above the bed (Photo 16).

The Hayat Cave is the most prominent form of the karst system called by its name. It was shaped by the Kavaklıgöl Creek. The stream is

it is possible that the cave was used by people. The cave has a relatively thick layer of soil and illegal archaeological excavations have been conducted. A salvage excavation can be done inside the cave to prove the situation.



Photo 14: Sawtooth drapery curtain shapes in the main hall.

pouring from two hanging springs into the cave. One of these resembles a small waterfall. A small plunge pool developed in front of it (Photo 17). In heavy rainy weather, the flood waters accumulated at the bottom of the Kavaklıgöl depression enter the cave through the swallow holes and distribute the volcanic pebbles and blocks brought from the source area throughout the cave's main gallery (Photo 18). However, on other days, the flow of the stream decreases and flows through between these blocks. After the stream flows 35 m along the main gallery, it sinks from a swallow hole (Photo 19). After this swallow hole was opened, the stream deepened its bed and a 70 cm elevation difference occurred with the gallery floor on the mouth side (Photo 19). For this reason, the part of the main gallery after the swallow hole is dry. However, pebbled terrace fillings observed 1 m high on the entrance of the main gallery, show that the stream passes through the cave and flows out of the entrance (Photo 20).



Photo 15: Entrance number 1 at the front of the Hayat Cave and small windows on the right.



Photo 16: Entrance number 2 of the Hayat Cave.



Photo 17: The Kavaklıgöl Creek when entering the cave, it creates a small waterfall and a plunge pool.



Photo 18: Basalt blocks dragged into the Hayat Cave by flood water.

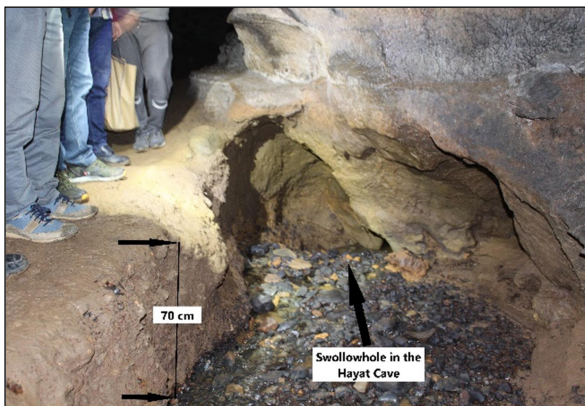


Photo 19: Swallow hole in Hayat Cave and vertical difference from exit side.



Photo 20: Pebbly terrace levels on the exit part of the Hayat Cave.



Photo 21: A pen in the mud deposit in the cave.



Photo 22: Abrasion shapes formed by the erosion of flood waters.

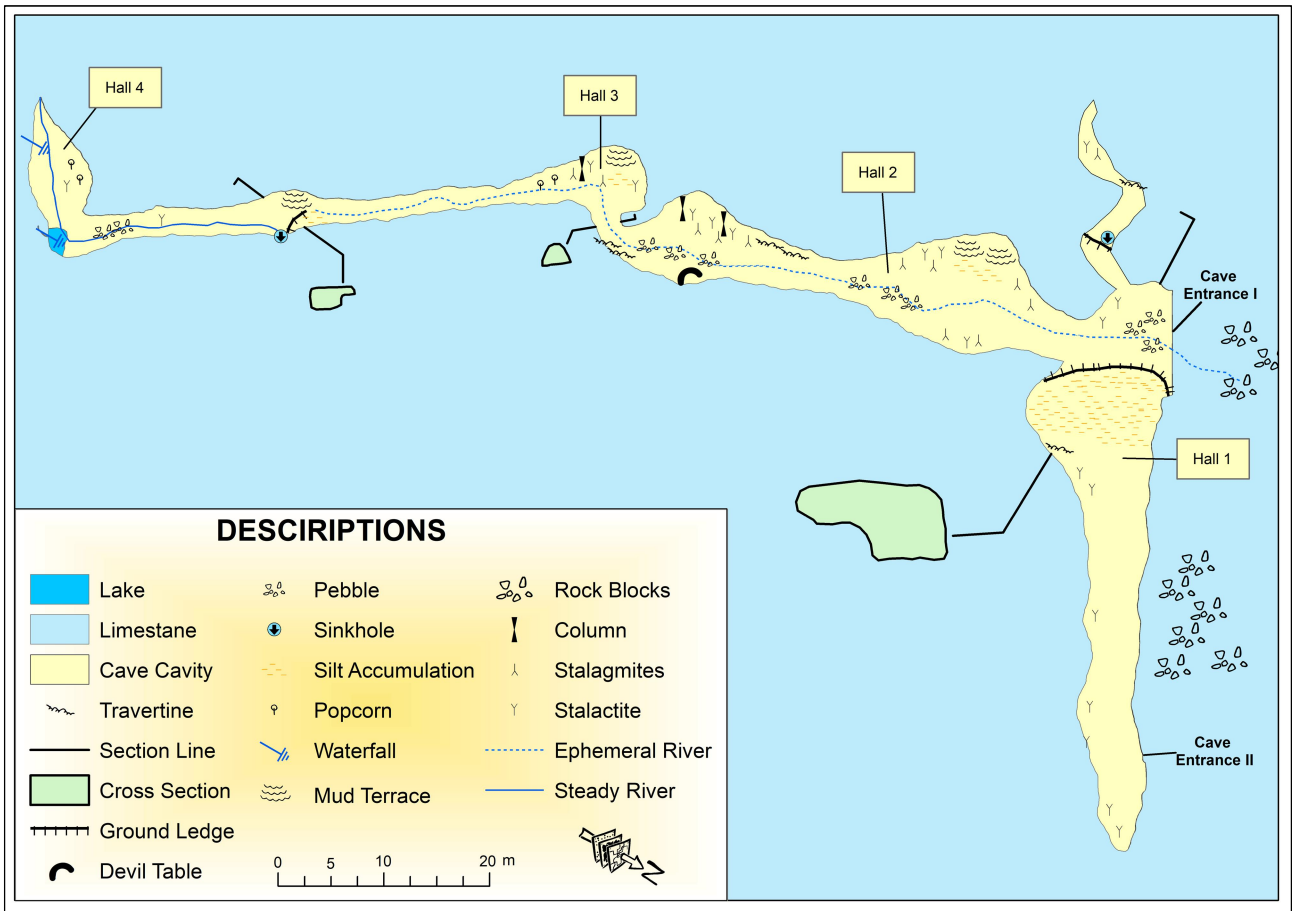


Figure 7: Plan of the Hayat Cave (Cave Plan was drawn by Faruk AYLAR).

The swallow hole in the cave cannot drain all the flood waters occur today. Therefore, rising flood waters discharge from the entrance of the cave into the valley. Meanwhile, tiny materials that form the water load are spread into the cave and accumulate. The fact that these mud depots without gravel and blocks are still fresh indicates that the river has overflowed recently (Photo 21). On the other hand, flood waters have formed the destructive shapes along the bed by abrading the wall speleothems (Photo 22).

Caves are usually closed environments and are hardly affected by the weather outside. Therefore, they often have their own climate. However, caves with an effective air and stream flow are more affected by the weather conditions outside. The average temperature of the cave air is generally close to the average temperature outside (Cigna, 2004). However, they are cool from the outside in summer and warm in winter. The Hayat Cave is an active cave, and the Kavaklıgöl Creek transfers energy into the cave from outside. In addition,

the fact that the cave has more than one entrance made it easier for the sections close to the entrance to be affected by the external atmosphere conditions. Indeed, during the field works, the temperature outside the cave was 14.1 °C and humidity was 81.7%; while 13.6 °C and 82% in Hall 1; 12.5 °C and 83% in Hall 3; and 11.7 °C and 86.9% in Hall 4 were measured respectively. Accordingly, the twilight zone (Hall 1) of the cave is severely affected by the weather outside. However, as



Photo 23: Wall speleothems in the Hayat Cave.

one enters the interior of the cave, the temperature and humidity conditions become more stable.

The Hayat Cave is not rich in dripstone formations like Bařaran Cave. However, there are some visually attractive dripstone shapes such as stalactites, stalagmites, flow stones, curtains and saw-toothed curtains in the cave (Photo 23). Also, moon milk formations developed in the cave (Photo 24).



Photo 24: Developed moonmilk shapes in the cave.

4. CONCLUSION

In this study, the Hayat Cave Karst system was investigated in a versatile way. The research area is located within the borders of Bařaran village of Bafra district of Samsun. The system has unique shapes of surface and depth karst. The main components of the system are the fluviocarstic depression in the east of the Bařaran village and the Bařaran and Hayat caves in the north of the village. Kavaklıgöl Creek spring from the south slopes of the fluviocarstic depression known by its name, and it sinks in the swallow holes on the northern edge of the depression. The stream has an underground flow of up to 600 m. The stream has formed two caves in a row during the underground flow. The Bařaran cave above is located in the vadose zone and is dry. The Hayat Cave below is active. The Kavaklıgöl Creek flows along the main gallery of the cave about 35 m. Although these caves are not rich in dripstones, they are home to dripstones with high visual appeal. In addition, biochemical

forms of moonmilk were found in the both caves.

Caves open to tourism support rural development. Therefore, local administrators are excited to open caves with tourism potential to tourism. However, opening the caves to tourism without sufficient research sometimes causes the expected income to not be obtained. Sometimes sensitive cave ecosystems suffer from overuse. For example, each visitor causes about 150 watts of energy transfer to the cave (Cigna, 2011). For that reason, before opening the Hayat Cave karst system for tourism, the potential of the system and the tourist attractions in its close environment must be investigated. Among the touristic attractions that can be studied for this purpose are Bakacak Rock, Kapıkaya, Kaya Cave, Tependlięi Cave, Koyunaęılı Cave, Asarkaya Castle, Asarkaya Rock Tombs and Akalan Waterfalls.

As a result, if Hayat Cave is opened to tourism, it can become a daily destination for nearby

settlements, especially Bafra. However, one should not hurry *the trio of environmental protection, visitor safety and profit* (Cigna, 2011) should be well calculated. In addition, if these caves are to be opened to tourism, some infrastructure improvements should be made, especially the transportation problem.

REFERENCES

- Akkan, E. (1970). *Geomorphology of Kızılırmak Valley Between Cape Bafra and Delice Junction*. Ankara University, Faculty of Language, History and Geography, Ankara.
- Berndt, C. & Yıldırım, C. & Çiner, A. & Strecker, M. R. & Ertunç, G. & Sarıkaya, M. A. & Özcan, O. & Ozturk, T. & Kiyak, N. G. (2018). Quaternary uplift of the northern margin of the Central Anatolia Plateau: New OSL dates of fluvial and delta-terrace deposits of the Kızılırmak River, Black Sea coast, Turkey. *Quaternary Science Reviews*, 201, 446-469.
- Cigna, A.A. (2004). Climate of caves. *Encyclopedia of caves and karst science*. London: Taylor & Francis, 467-475.
- Cigna, A.A (2011). Show cave development with special references to active caves. *Tourism and Karst Areas* 4, 7-16.
- Cigna, A.A. and Burri, E. (2000). Development, management and economy of show caves. *International Journal of Speleology*, 29, 1.
- Ford, D.C. & Williams, P.W. (1989). *Karst Geomorphology and Hydrology*. Academic Division of Unwin Hyman Ltd, pp. 601, London.
- Gillieson, D. (1998). *Caves: processes, development and management*, Blackwell Publishers.
- Ketin, İ. & Gümüş, O. (1963). *Between Sinop and Ayancık III. Report on the Geology of the Areas Included in the Region*. TPAO.
- Nazik, L. & Tuncer, K. (2010). Regional features of Turkey karst morphology. *Turkish Journal of Speleology* 1, 7-19.
- Öner, E. (1990) Physical Geography of Samsun and Surroundings, Ph.D. Thesis, Ankara University Ankara.
- Özkök, H. (2019) Tourism Geography of Derbent Dam Lake and Its Surroundings, Master Thesis, Ondokuz Mayıs University, Samsun
- Samsun Provincial Culture and Tourism Directorate (2020) <https://samsun.ktb.gov.tr/TR-240669/hayat-kayasi-magarasi.html> (Accessed 5rd February 2020).
- TSMS (2019). Bafra Meteorology Station Observatory Data. *General Directorate of State Meteorology Affairs*.
- Uzun, A. (1995a). Geomorphology of Gerze Alaçam Coastal Region, 1. baskı/Ed., Öz Eğitim.
- Uzun, A. (1995b). Cave-fortress settlements in Tekkeköy (Samsun). *Eastern Geography Magazine* 1.
- Uzun, A. (2004a). Karst morphology of Mount Yaraligöz and its close surrounding, Northern Anatolia, Turkey. In "Proceeding of International Symposium on Earth System Sciences 2004, İstanbul – Turkey", pp. 513-519, İstanbul.
- Uzun, A. (2004b). Koru Polje and karst landform evolution in the middle part of the Kure Mountains, Northern Anatolia, Turkey. *Cave and Karst Science* 31, 109-112.
- Vuković, S., and Antić, A. (2019). Speleological approach for geotourism development in Zlatibor county (West Serbia). *Turizam* 23, 53-68.
- Yılmaz, C. (2007). Human and Economic Geography of the Bafra Plain. II. Printing, Kızılırmak Offset, Samsun.