



KEF EL GHAR CAVE (TAZA, MOROCCO): GEOLOGICAL, HYDROLOGICAL, ECOLOGICAL AND CULTURAL SIGNIFICANCE OF A KARST GEOSITE

JAMA KEF EL GHAR (TAZA, MAROKO): GEOLOŠKI, HIDROLOŠKI, EKOLOŠKI IN KULTURNI POMEN KRAŠKEGA GEOLOŠKEGA OBMOČJA

Saida BOUAZZA^{1*}, Kaoutar BARGACH¹, Abdelkarim NAJIM², Abderrahmane OUCHKAR¹, Imane EDDIFAI³ & Younes EL KASSMI⁴

Abstract

Saida Bouazza, Kaoutar Bargach, Abdelkarim Najim, Abderrahmane Ouchkar, Imane Eddifai & Younes El Kassmi: Kef El Ghar cave (Taza, Morocco): Geological, hydrological, ecological and cultural significance of a karst geosite

Kef El Ghar cave, located in the Taza region of northeastern Morocco, is a remarkable karst feature of significant natural and cultural value. This study aims to characterize the cave's geodiversity and assess its significance as a karst geosite. Field investigations and descriptive analyses reveal well-developed karst morphologies, stratigraphic exposures, active hydrological systems, and diverse speleothems, highlighting the cave's natural significance. In addition, evidence of historical human use, archaeological traces, and aesthetic features emphasize its cultural importance. Despite these attributes, the site faces increasing threats from uncontrolled access, lack of formal protection, and anthropogenic degradation. Based on these findings, this study proposes conservation and management strategies to preserve the cave's integrity and promote its integration into regional geotourism and public education initiatives. Kef El Ghar cave thus represents a valuable component of the karst heritage of the Taza region and supports initiatives aimed at the establishment of a regional geopark.

Keywords: Kef El Ghar cave, natural and cultural heritage, geo-heritage, conservation strategies, tourism.

Izvleček

Saida Bouazza, Kaoutar Bargach, Abdelkarim Najim, Abderrahmane Ouchkar, Imane Eddifai & Younes El Kassmi: Kef El Ghar cave (Taza, Morocco): Jama Kef El Ghar (Taza, Maroko): geološki, hidrološki, ekološki in kulturni pomen kraškega geološkega območja

Jama Kef El Ghar, ki je v regiji Taza na severovzhodu Maroka, je izjemen kraški pojav z velikim naravnim in kulturnim pomenom. Cilj te študije je opredeliti geološko raznovrstnost jame in proučiti njen pomen kot kraškega geološkega območja. Terenske raziskave in opisne analize razkrivajo dobro razvite kraške oblike, stratigrafske plasti, aktivne hidrološke sisteme ter raznovrstne jamske tvorbe, kar poudarja naravni pomen jame. Poleg tega kulturni pomen jame poudarjajo dokazi o zgodovinski človeški rabi, arheološke sledi in estetske značilnosti. Ob teh značilnostih je območje čedalje bolj ogroženo zaradi nenadzorovanega dostopa, pomanjkljive uradne zaščite in poškodovanja zaradi antropogenih aktivnosti. Na podlagi teh ugotovitev se v tej študiji predlagajo strategije ohranjanja in upravljanja, ki bodo zagotovile ohranitev celovitosti jame ter spodbudile njeno vključitev v regionalne pobude na področju geoturizma in izobraževanje javnosti. Jama Kef El Ghar je tako dragocen del kraške dediščine regije Taza in podpira pobude, katerih cilj je ustanovitev regionalnega geoparka.

Ključne besede: jama Kef El Ghar, naravna in kulturna dediščina, geodediščina, strategije ohranjanja, turizem.

¹ Geo-Biodiversity and Natural Patrimony Laboratory (GEOBIO), Scientific Institute, Mohammed V University in Rabat, Avenue Ibn Batouta, P.B. 703, 10106 Rabat-Agdal, Morocco, e-mail: saidabouazza9@gmail.com

² National Institute of Geophysics, National Center for Scientific and Technical Research (CNRST), Rabat, Morocco

³ Laboratory of Geosciences, Faculty of Sciences, Ibn Tofail University, B.P. 133, 14000 Kénitra, Morocco

⁴ Nature Guide, Independent researcher, Taza, Morocco

* Corresponding Author

1. INTRODUCTION

Caves, essential components of karst systems, are valuable archives of geomorphological processes resulting from the interaction of geological, hydrological, and biological factors (Gray, 2004). As integral elements of karst aquifers, caves preserve valuable records of past environmental conditions, including palaeoclimatic fluctuations, sedimentary processes, and, in some cases, evidence of past human presence. Their scientific relevance, combined with ecological and cultural values, places caves among the most significant elements of terrestrial geodiversity (Cigna and Forti, 2013). Despite their scientific relevance and undeniable ecological value, many karst environments are currently threatened by human activities. Among the main causes of these threats are uncontrolled visits, pollution and changes in land use (De Waele, 2009).

In Morocco, karst landscapes occupy more than 100,000 km² and are mainly developed within Mesozoic carbonate formations of the Middle Atlas, High Atlas, Rif, and parts of the Anti-Atlas. These regions host a large number of caves and karst systems formed under varied structural and climatic conditions. Although several emblematic caves, such as Friouato cave and Win-Timdouine cave, have been the subject of speleological exploration and scientific studies due to their exceptional dimensions and hydrological significance, systematic research on Moroccan caves remains uneven. Many sites are still poorly documented and remain outside any for-

mal geoconservation framework (Hili & El Khalki, 2017; Baadi et al., 2021). The Taza region is particularly notable in this regard, being recognized as a karst-rich area characterized by a high density of caves and karst landforms.

This study is conceptually framed within international approaches to geoconservation and geoheritage assessment, which emphasize the integration of scientific, educational, and management perspectives (Gray, 2004; Prosser et al., 2006). Methodologically, it is informed by geosite assessment frameworks developed by Brilha (2016) and Reynard et al. (2016), which provide criteria for evaluating the scientific and heritage significance of geological sites and for supporting decision-making in conservation planning.

The focus of this study is the Kef El Ghar cave, located in the Taza region of northeastern Morocco. The main objective is to provide a detailed characterization of the cave by integrating geological, ecological, and cultural perspectives. The study combines bibliographic research, cartographic analysis, and field investigations to describe the cave's morphology, geological setting, and ecological conditions. The collected information is used to discuss the site's scientific and heritage value, identify existing threats, and propose appropriate conservation and management measures. By doing so, this work contributes to a better understanding of Moroccan karst systems and supports future geoconservation initiatives at the regional scale.

2. STUDY AREA: GEOLOGICAL AND GEOGRAPHICAL SETTING

2.1 GEOGRAPHICAL CONTEXT

The Kef El Ghar cave, located at an altitude of approximately 570 m a.s.l., lies about 37 km northeast of Taza city, within the municipality of Kef El Ghar in the Fez-Meknes administrative region (Figure 1). It is situated in a distinctive physiographic setting at the interface between the Rif mountain range, where elevations commonly exceed 1,500–2,000 m, and the alluvial plains of the Sebou Valley, which generally lie below 300 m a.s.l. This transitional position results in a karst landscape dominated by limestone hills, rocky outcrops, and closed depressions. Based on speleological surveys, the cave has a mapped length of approximately 1 km.

The morphology of this landscape is directly governed by the regional Mediterranean climate, which is characterised by strong seasonality. The alternation be-

tween mild, wet winters and hot, dry summers is the main driver of karstification. Mean annual temperatures range between 15 and 18 °C, while annual precipitation generally varies between 500 and 700 mm, concentrated mainly during the winter season. During the rainy season, infiltrating water gravitationally flows downward through the network of fractures in the carbonate host limestone, leading to progressive dissolution and contributing to speleothem formation within the cave.

Ecologically, the surrounding vegetation is Mediterranean scrub, mainly composed of holm oak (*Quercus ilex*) and juniper (*Juniperus spp.*), as well as other shrub species adapted to summer water constraints. This vegetation not only contributes to soil stabilisation, but also demonstrates the ecosystem's adaptation to climatic contrasts.

The environmental setting of the Kef El Ghar cave is notable for its representation of a model of dynamic interaction between geological settings, climatic forces and biological responses, sometimes acting simultaneously. This interdependence endows the site with considerable scientific interest for geoscientific studies and the conservation of natural heritage.

2.2 GEOLOGICAL CONTEXT

The study area is part of the eastern outer Rif structural domain. This region is a complex transition zone between the Rif mountain range to the north and the Middle Atlas to the south (El Kadiri et al., 1992), and lies at the junction of several major fault corridors, including the north-central Atlas fault zone. This tectonic setting results from the inversion of Mesozoic basins during the convergence between the African and Eurasian plates, which generated significant folding and thrusting during the Tertiary period (Frizon de Lamotte et al., 2008). More recent deformation is related to an NNW–SSE to NW–SE compressional regime, responsible for ongoing seismicity and brittle deformation affecting the rock massifs of the region (Ait Brahim et al., 2002).

Lithostratigraphically, the area is predominantly

underlain by a thick sequence of Mesozoic carbonate formations, including Jurassic units (Lias–Dogger) deposited in a shallow marine platform environment (Michard, 1976). These units, composed mainly of massive limestones and dolomites, constitute favourable host rocks for karst development.

Karstification is particularly well developed in the region due to the combined effect of the high solubility of carbonate rocks and the dense network of fractures and faults affecting the Jurassic formations. At the regional scale, these structural discontinuities, inherited from earlier tectonic phases and locally reactivated during neotectonic deformation, control groundwater flow paths by providing preferential infiltration and drainage zones. At the scale of Kef El Ghar cave, field observations indicate that the orientation and density of fractures strongly influence the spatial organization of underground galleries.

The Jurassic stratigraphic sequence is locally overlain by Lower Cretaceous carbonates and unconformable Miocene deposits. These Miocene units, composed of marls and sandstones ranging from the Lower Miocene to the Tortonian (Upper Miocene), were deposited within the Rif foreland basin during major collisional phases (Sani et al., 2007). The alternation of marine sedimenta-

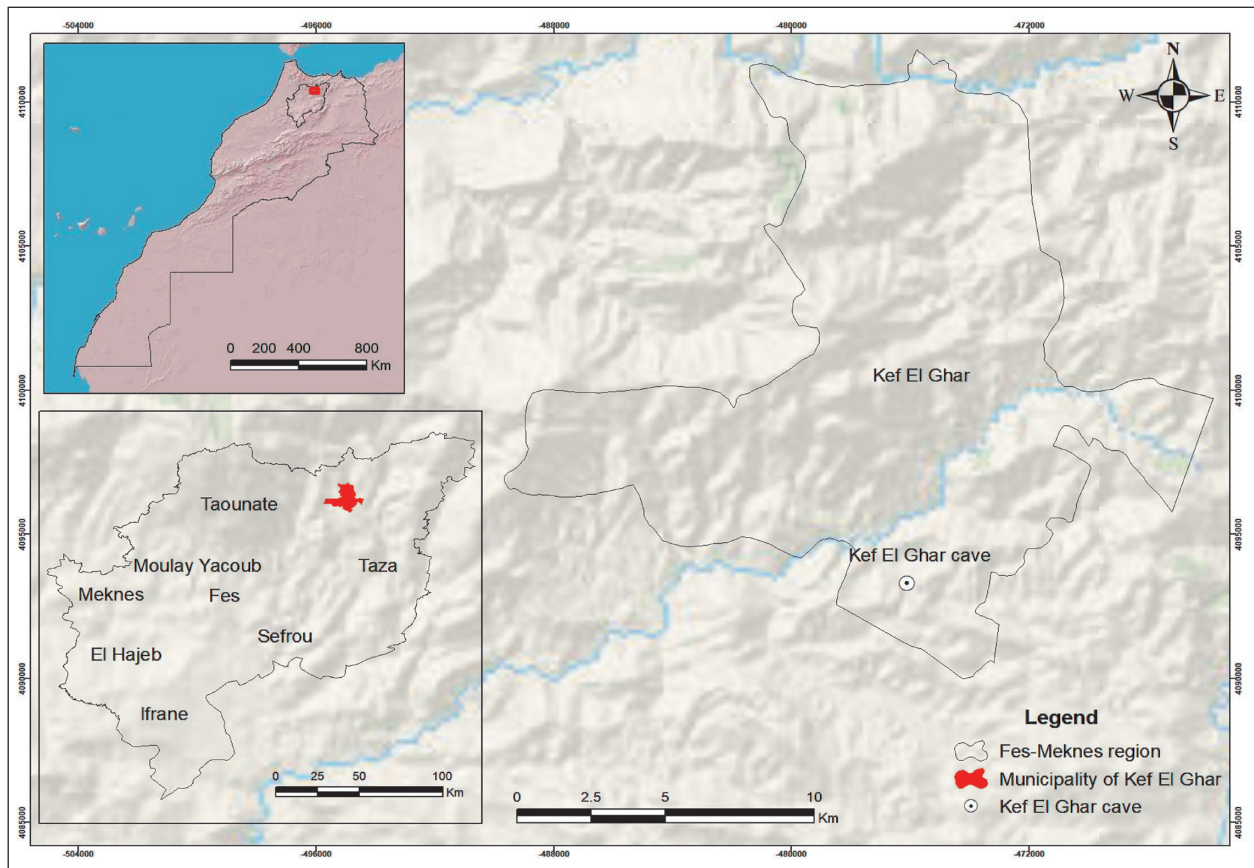


Figure 1: Geographical location of Kef El Ghar cave (Source: Esri imagery).

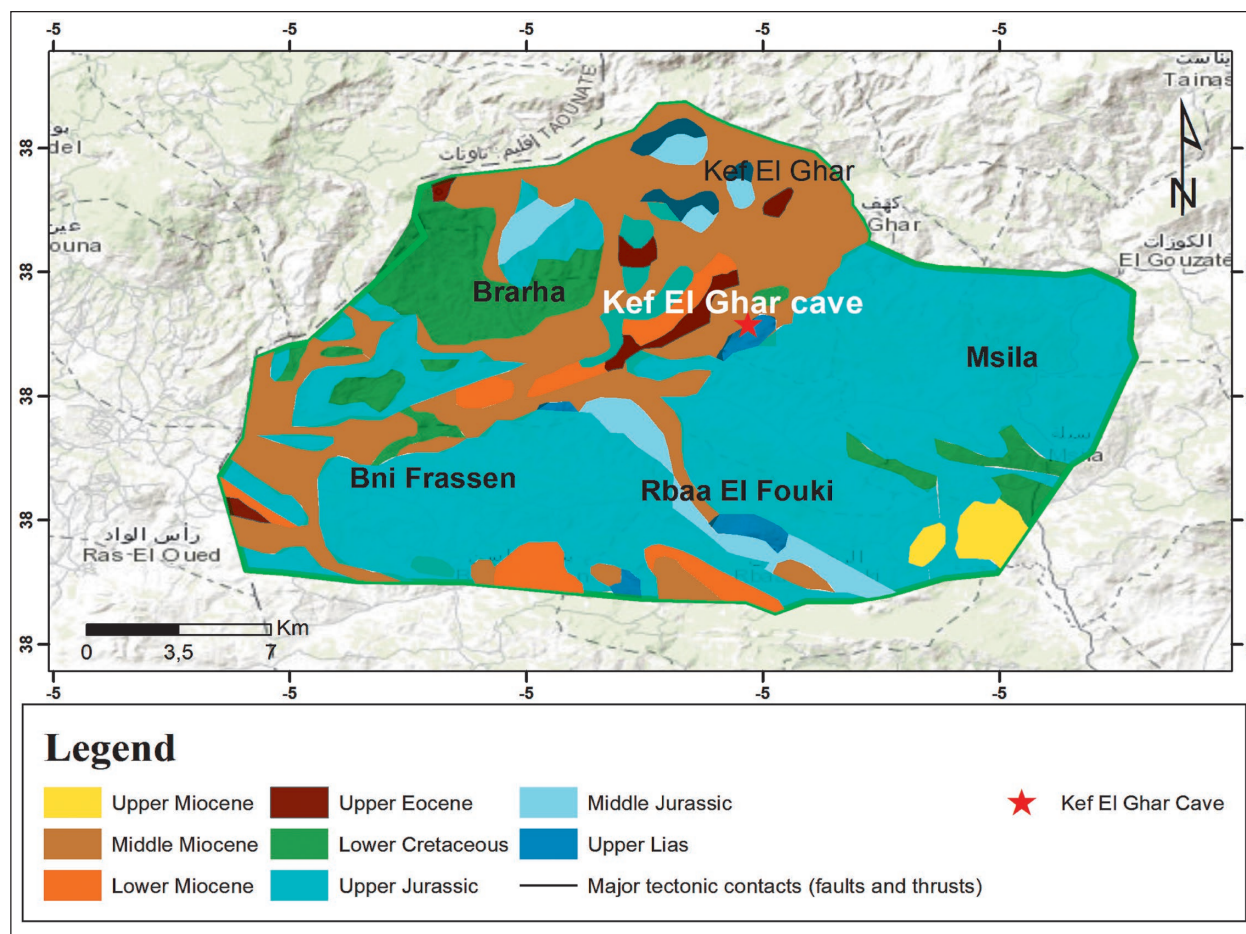


Figure 2: Geological map of the Kef El Ghar area, extracted and simplified from the Geological Map of the Rif Chain at 1:500,000 (Service Géologique du Maroc, 1985).

tion and tectonic reactivation reflects the complex tectonic history of the southern Rif margin.

Structural analysis, based on interpretation of the geological map of the Rif mountain range (Moroccan Geological Survey) and field observations, confirms that the Jurassic limestones are affected by several families of faults, mainly oriented NE–SW and E–W. These fault systems result from a polyphasic tectonic evolution. The NE–SW-oriented faults are commonly interpreted as structures inherited from Mesozoic rifting and later reactivated during Alpine compression (Frizon de Lamotte et al., 2008),

whereas the E–W-oriented faults are more likely related to post-Tortonian compressional phases that contributed to the final structuring of the Rif foreland (Morel, 1989).

Ultimately, the genesis of the Kef El Ghar cave reflects a dual control. While the carbonate nature of the host rocks enabled dissolution processes, polyphasic tectonic fracturing played a decisive role by guiding water infiltration and flow trajectories. This structural control guided the development of underground galleries, whose spatial organization reflects the tectonic evolution of the region rather than a single geological event.

3. MATERIALS AND METHODS

The study adopted a descriptive and integrative methodological approach combining bibliographic review, cartographic analysis, and field observations. Existing geological and speleological data, including the Geological Map of the Rif Chain and the topographic survey of the Kef El

Ghar cave by Pierret and Siguier (1963), were analysed to establish the geological framework of the study area.

Fieldwork campaigns were carried out to document the morphology, geological structures, and ecological characteristics of Kef El Ghar cave. GPS measurements

Table 1: Main features of Kef El Ghar cave.

Location	Access	Dimensions	Geomorphological description
Region: Taza, northeastern Morocco Entrance Coordinates: 34°28'45.0" N, 4°16'37.1" W Entrance altitude: ~570 m a.s.l. Nearest city: 37 km northeast of Taza city	Accessible via local roads from Taza, followed by a footpath of approximately 300 m (about 5 minutes of walking) leading to the cave entrance.	Mapped length: ~1 km (based on the speleological survey by Pierret & Siguier, 1963)	Host rock: Jurassic limestone Age of host rock: Mesozoic Cave type: Subhorizontal karst cave, periodically water-active

were conducted outside the cave to record the geographical position of the site and its main entrances, while photographic documentation and direct observations were used inside the cave to record visible karst features such as chambers, speleothems, and water drainage. Observations of the surrounding environment, vegetation, and faunal activity were also noted to better understand the ecological context of the cave.

In terms of geometry, Kef El Ghar is predominantly a horizontal cave system composed of interconnected galleries and large chambers, with local vertical steps. Hydrologically, the cave shows active percolation and seasonal water occurrence; standing or flowing water was observed in some passages during wet-season visits, whereas drier conditions prevailed during summer observations. Given the limited number of visits, the hydrological functioning is described here qualitatively, based on field evidence, rather than classified into a strict phreatic or vadose typology.

The collected information was synthesized to produce a comprehensive description of the cave's geological and ecological features. The interpretation and discussion of the results were guided by the international frameworks proposed by Brilha (2016) and Reynard et al. (2016), which define the main criteria for assessing the scientific, educational, and heritage value of geosites. These references provided a theoretical basis for evaluating the significance of Kef El Ghar cave within the broad-

er context of Moroccan karst heritage and for developing appropriate conservation and management recommendations.

The total mapped length of the cave is approximately 1 km, based on the speleological survey by Pierret and Siguier (1963). More recent investigations describe an accessible main conduit of approximately 660 m (Dbiba et al., 2025), which likely corresponds to the principal surveyed gallery. Longer underground extensions have been suggested in the literature but have not been surveyed or confirmed and are therefore not considered here.

3.1 EXTERIOR DESCRIPTION

The Kef El Ghar cave is easily accessible via local trails that cross a varied landscape of surrounding mountains and valleys. The cave entrance is marked by two large openings located on opposite sides of the limestone ridge, allowing access to the cave from different directions. The external environment is characterized by typical Mediterranean vegetation dominated by holm oaks (*Quercus ilex*), junipers (*Juniperus* spp.), and various drought-resistant shrubs.

3.2 INTERIOR DESCRIPTION

The Kef El Ghar cave has approximately 1 km of mapped passages and is composed of vast chambers interconnected by underground galleries forming a continuous internal passage between the upstream and downstream

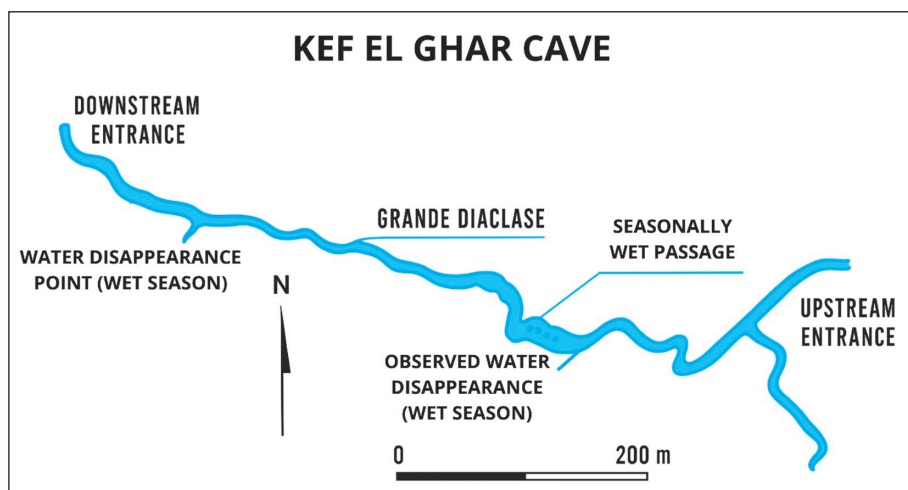


Figure 3: Topographic map of Kef El Ghar cave (original survey by B. Pierret and Siguier (1963); modified by the author).

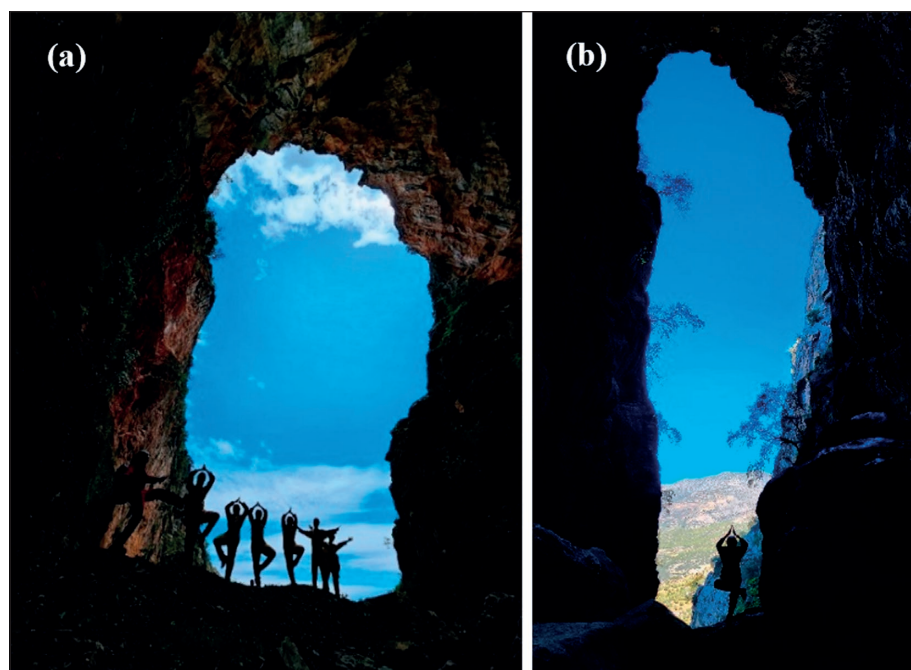


Figure 4: The two main entrances of Kef El Ghar cave: (a) downstream entrance; (b) upstream entrance (Photograph by the author).

entrances. Several chambers are characterized by large dimensions and contain abundant speleothems, including stalactites, stalagmites, columns, and mineral draperies. The topographic map of the cave illustrates the spatial organization of these chambers and passages (Figure 3).

The cave was first documented in 1917 by Campardou, later explored by Casteret in 1934, and topographically mapped by Pierret and Siguier in 1963. Although locally known for centuries, its scientific exploration began in the mid-20th century. Early speleological descriptions of caves in the Taza region, including those reported in the *Bulletin du Groupe Spéléo Bagnols Marcoule (Spécial Maroc)*, provided valuable historical context and contributed to the documentation of regional cave exploration.

3.3 TOPOGRAPHY OF THE CAVE

The cave network exhibits a predominantly subhorizontal organization composed of interconnected galleries and spacious chambers. Its spatial configuration is strongly controlled by fracture systems and bedding planes, which guided dissolution processes and determined the orientation and connectivity of passages (Figure 3).

The cave has two upstream entrances, the larger of which is referred to as “Porche Amont” (Figure 4b), and one wider downstream entrance known as “Porche Aval” (Figure 4a). Internally, chambers are connected through fracture-guided conduits, reflecting structural control on speleogenesis. This structural control results in a longitudinal gallery pattern aligned with the dominant fracture directions.

Hydrological observations during wet-season visits indicate localized dripping and temporary water flow

along fractures and conduits. In some sectors, water was observed descending into lower, inaccessible passages, suggesting drainage toward deeper karst levels. During dry-season visits, only minor seepage was recorded. Given the limited monitoring period, the hydrological functioning is described qualitatively without assigning a permanent phreatic or vadose classification. These observations suggest a seasonally active drainage system rather than a permanently flowing subterranean stream.

The distribution of speleothems within different chambers reflects variations in water infiltration patterns and geochemical conditions, illustrating localized differences in karst dynamics (Figure 5). Speleothem concentrations are generally associated with zones of enhanced infiltration and fracture intersections.

3.4 FAUNAL ASPECTS

Kef El Ghar cave hosts a subterranean ecosystem characterized by permanent darkness, relatively stable temperatures, and high humidity, providing suitable roosting conditions for several bat species. During our field visits, bats were observed roosting mainly in the entrance and intermediate zones of the cave. These observations were qualitative, and no systematic counts, captures, or acoustic monitoring were conducted within the framework of the present study.

Recent chiropterological investigations conducted in the cave (Dbiba et al., 2025) documented four bat species: *Miniopterus schreibersii*, *Myotis punicus*, *Rhinolophus euryale*, and *Eptesicus isabellinus* (Figure 6). The study confirmed the presence of large maternity colonies of *M. schreibersii* and *M. punicus*, which represent the

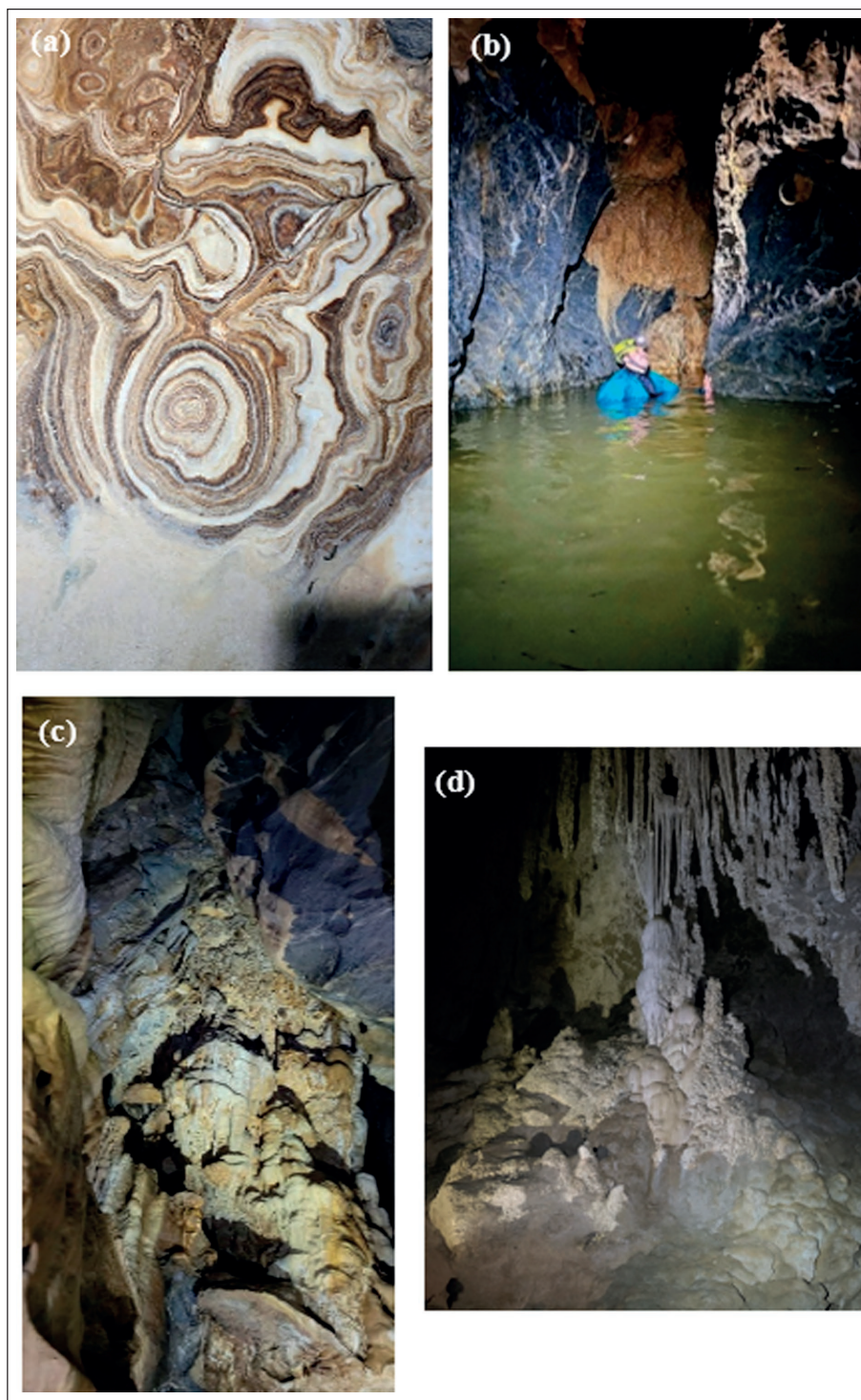


Figure 5: Representative features of the Kef El Ghar cave. (a) Laminated calcite flowstone; (b) Submerged karst passage; (c) Massive flowstone draperies; (d) Stalactitic and stalagmitic formations (Photograph by the author).

dominant species within the cave. In contrast, *R. euryale* and *E. isabellinus* were recorded in much lower abundance, the latter being detected acoustically.

In addition to bats, terrestrial invertebrates were observed on cave walls, gallery floors, and in guano-rich areas. However, no formal taxonomic identification was conducted as part of the present study. Guano deposits

are known to support specialized microfaunal communities characteristic of oligotrophic karst ecosystems.

Although the bat assemblage has recently been documented (Dbiba et al., 2025), comprehensive biospeleological investigations remain necessary to establish a complete inventory of cave-dwelling fauna, particularly invertebrate and microfaunal communities.

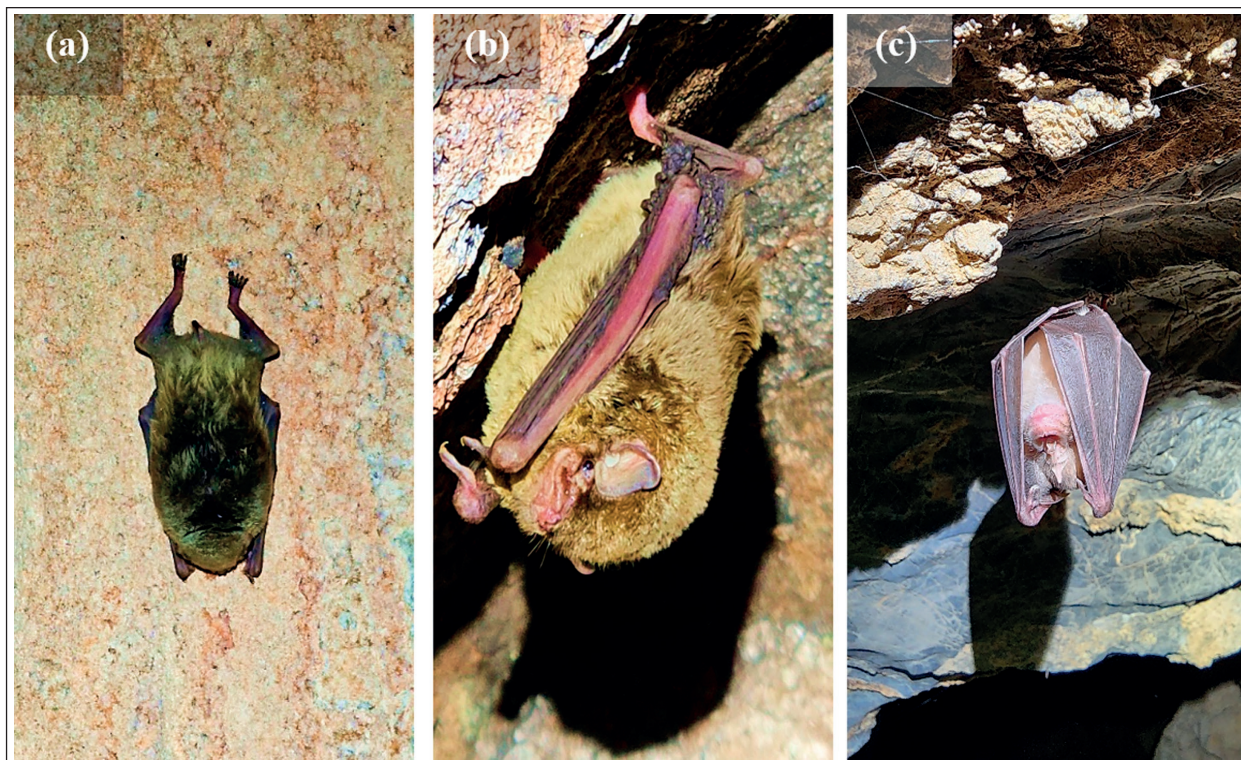


Figure 6: Bats observed inside Kef El Ghar cave: (a) *Miniopterus schreibersii*; (b) *Pipistrellus* sp.; (c) *Rhinolophus* sp. (Species attribution based on external morphological characteristics. Photographs by the author).

4. RESULTS: NATURAL AND CULTURAL SIGNIFICANCE OF KEF EL GHAR CAVE

4.1 NATURAL (GEOLOGICAL AND ECOLOGICAL) SIGNIFICANCE

Kef El Ghar cave represents a remarkable example of karst morphology developed within Jurassic carbonate formations. It developed through prolonged dissolution of limestone by groundwater, which led to the creation of an extensive subterranean network composed of large chambers and interconnected galleries.

The stratigraphy visible along the walls of the cavity reveals several sedimentation levels that reflect different stages of regional geological evolution. The cave also exhibits active hydrological features, including sinking points interpreted as ponor-like features, localized resurgences, and fracture-controlled groundwater flow pathways, indicating ongoing karst processes. Although the precise direction and continuity of water flow have not been fully established, field observations confirm the role of structural discontinuities in guiding water flow. These characteristics confer high scientific significance upon the cave as a natural laboratory for the study of karst hydrogeology and speleogenesis in the Taza region.

The morphological variety and structural complexity of speleothems are a direct expression of variations in cal-

cium carbonate precipitation processes. The internal stratifications and changes in texture of these concretions constitute sedimentary archives that bear witness to the different phases of deposition, driven by fluctuations in the hydrological and geochemical parameters of the environment.

In addition to speleothem formations, localized clastic sediment accumulations were observed in several sectors of the cave, particularly along low-gradient gallery floors. These deposits consist predominantly of fine-grained materials such as silts and sandy infills, most likely transported during episodic high-water events. Although no detailed sedimentological analyses were conducted within the framework of the present study, field observations indicate that these clastic deposits reflect phases of internal sediment transport associated with seasonal hydrological variability. Future sedimentological investigations would help clarify their stratigraphic organization and paleoenvironmental significance.

From an ecological perspective, Kef El Ghar cave also presents biological significance. Field observations indicate the presence of cave-associated fauna, including bat populations (trogloxenes) and invertebrates, which contribute to the biological value of the subterranean eco-

Table 2: Summary of the natural significance of Kef El Ghar cave.

Structural features	Host rock stratigraphy	Cave sedimentary deposits	Hydrological characteristics	Speleothems and paleoenvironmental indicators	Ecological features
Fracture systems, faults, and bedding planes controlling groundwater flow and karst conduit development	Jurassic limestone formations forming the carbonate host rock of the cave system	Localized clastic sediment infills (silts and sandy materials) reflecting episodic internal sediment transport during high-water flow events	Infiltration zones and localized sinking points with structurally controlled groundwater flow and episodic high-water events	Stalactites, stalagmites, columns, and calcite draperies providing potential paleoenvironmental records	Presence of cave fauna including bats and terrestrial invertebrates in guano-rich zones

system. The relative environmental stability of the cave enhances its importance as a habitat within the regional karst landscape.

The main components of the natural significance are summarised in Table 2.

Together, these natural attributes demonstrate that Kef El Ghar cave constitutes a site of high geoheritage value within the karst landscapes of northeastern Morocco.

4.2 CULTURAL AND HISTORICAL SIGNIFICANCE

Kef El Ghar cave also holds cultural and historical importance within the regional context of the Taza area. Although the cave has not been the subject of extensive archaeological excavation, its large and accessible entrances may have historically facilitated human presence and occasional use (Pierret and Siguier, 1963).

Local oral traditions associate the cave with episodes of temporary shelter and pastoral activities, reflecting its integration within the surrounding rural landscape. The downstream entrance, characterized by its wide opening and natural illumination, may have served as a natural refuge or stopping point for shepherds and travellers.

In addition to its local cultural relevance, the cave has attracted scientific attention since the mid-20th century, notably through early topographic surveys and speleological explorations. These studies contributed to the broader understanding of karst development in the Taza region and represent part of the scientific heritage associated with the site.

The cultural value of Kef El Ghar is therefore expressed not only through potential historical use, but also through its scientific legacy and its role in regional speleological exploration.

5. DISCUSSION

5.1 NATURAL AND CULTURAL SIGNIFICANCE OF KEF EL GHAR CAVE

The multidisciplinary assessment confirms that Kef El Ghar cave represents a structurally controlled karst system developed within fractured Jurassic limestones and illustrates the interaction between lithology, tectonic inheritance, and seasonal hydrological variability (Ford & Williams, 2007).

Beyond its geoscientific relevance, the cave also holds ecological and cultural significance. The presence of troglodyte bat populations and evidence of occasional historical use contribute to its broader heritage interest. However, no archaeological material was documented during this study, and further interdisciplinary research would be required to confirm the extent of past human occupation.

Table 3: Summary of the cultural and historical significance of Kef El Ghar cave.

Subcategory	Description
Archaeological interest	Possible prehistoric occupation based on local testimonies and the accessibility of cave entrances (requires archaeological verification).
Traditional use	Use as temporary shelter by pastoral communities.
Intangible heritage	Local oral traditions and narratives associated with the cave.
Scientific exploration history	Early speleological surveys and documented exploration since the mid-20th century.

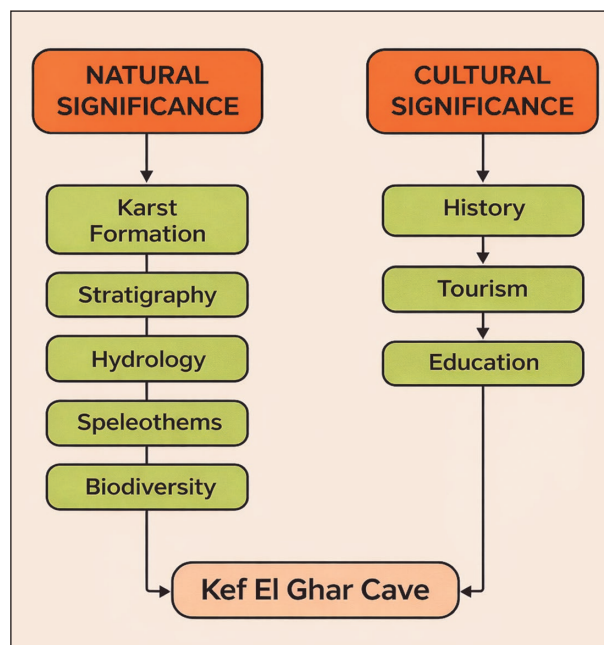


Figure 7: Conceptual diagram illustrating the natural and cultural values of Kef El Ghar cave.

These complementary dimensions are summarized in a conceptual diagram (Figure 7).

5.2 THREATS AND VULNERABILITY

As the cave currently has no formal legal protection status, long-term conservation would require official recognition within regional or national geoconservation policies. Field observations indicate anthropogenic impacts such as graffiti, littering, and localized speleothem damage. Compared to nearby sites such as Friouato cave, which benefits from structured visitation and basic infrastructure, Kef El Ghar remains unmanaged.

At the regional scale, the Taza area constitutes one of the most significant karst areas in Morocco. Integrating Kef El Ghar into a coordinated network of geosites would strengthen geoconservation initiatives and contribute to sustainable territorial development aligned with geopark principles.



Figure 8: Conceptual framework for the conservation and valorisation of the karstic heritage of the Taza region.

5.3 CONSERVATION AND MANAGEMENT

Kef El Ghar cave represents a valuable karst geosite requiring targeted conservation measures. Current pressures are mainly related to uncontrolled visitation and the absence of regulatory frameworks. Preventive actions should prioritize non-intrusive management strategies, including visitor awareness, minimal signage, and periodic scientific monitoring.

Rather than promoting isolated site development, a coordinated approach linking Kef El Ghar with other karst sites in the Taza region could support balanced geotourism while reducing localized pressure.

Such an integrated perspective aligns with international geopark principles and could enhance both scientific research and sustainable local development.

The proposed framework highlights the complementarity between local conservation actions and broader territorial planning, including the application of geopark principles at the regional scale (Figure 8).

6. CONCLUSIONS

In conclusion, Kef El Ghar cave represents a geosite of high natural and cultural heritage significance within the karst landscapes of the Taza region. Its geological properties, hydrological dynamics, ecological components, and

cultural traces collectively demonstrate its multi-dimensional heritage value.

However, the absence of formal protection and increasing human pressure highlight the urgency of

implementing appropriate conservation measures. A management approach based on controlled access, scientific monitoring, and public awareness would help ensure long-term preservation while maintaining the site's integrity.

At a broader scale, integrating Kef El Ghar into a regional karst heritage framework could strengthen geo-conservation strategies and contribute to sustainable territorial development consistent with geopark principles.

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