



Research Article

# Geological Marvels of Kolah Qazi National Park, Central Iran: Middle Jurassic–Late Cretaceous Strata and Invertebrate Richness

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## Abstract

Kolah Qazi National Park preserves a diverse assemblage of stratigraphic and paleontological features, which attract both scientists and visitors. The park hosts twelve unique geosites, each revealing different chapters of Earth's history through well-preserved fossils and distinctive stratigraphy. Highlights include evidence of the Albian Oceanic Anoxic Event, a major paleoceanographic perturbation, and newly identified seep carbonates. These features position Kolah Qazi as a strong candidate for national geopark designation. Such recognition would formally acknowledge its geological significance and enhance its role in education, research, and structured geotourism development while supporting effective conservation management.

**Keywords:** Geotourism, Geopark, Geoheritage, Oceanic Anoxic Event, Seep Carbonates, Ammonites

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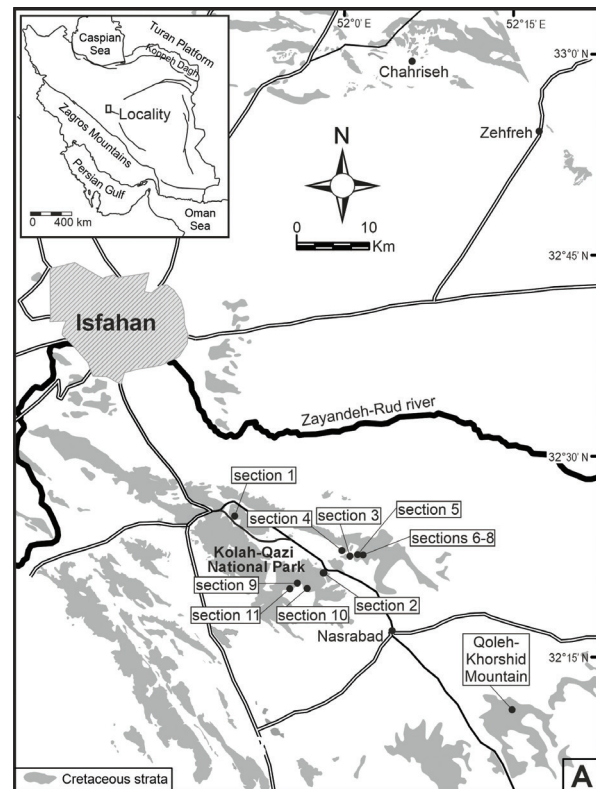
## Introduction

Tourism is one of the world's largest and fastest growing industries, driving a concurrent rise in geotourism, which connects people with Earth's geological heritage (Hose 1995, 2006; Guerini *et al.* 2024). Geotourism promotes awareness of natural landscapes, enhances understanding of geological features, and supports both conservation efforts and local communities (Lima *et al.* 2013). However, sustainable management is essential to balance tourism development with the long-term preservation of geoh heritage sites (Larwood and Prosser 1998).

In recent decades, geotourism has expanded rapidly, particularly in rural areas and geoparks (Kavčič and Peljhan 2010). Its growth since the early 21st century is largely due to the establishment of the geopark concept (Dowling 2011). Hose (2012) emphasizes that an understanding of "geohistory", the systematic exploration of geological discoveries in relation to contemporary socio-economic and cultural trends, is essential for a modern approach. Geoconservation, another vital aspect, aims to protect geosites and geomorphosites from degradation (Cleal *et al.* 1999; Kubalíková and Kirchner 2016). This practice preserves crucial resources for research and education while reinforcing their role in long-term development (Henriques *et al.* 2011; Raharimahefa 2013; Ruban 2015).

Geoparks are territories with internationally significant geological heritage, managed through an integrated framework that links conservation, education, and sustainable development (UNESCO 2006). These protected areas encompass geologically rare, scenic, or scientifically significant sites, integrating conservation with public education, community involvement, and environmentally responsible tourism (Dowling 2011; UNESCO 2006).

Geosites are specific geological locations valued for their scientific, aesthetic, and educational importance. As fundamental elements of geoh heritage, they require systematic assessment to determine their condition, conservation significance, and po-



**Figure 1.** Location map of Kolah Qazi National Park, central Iran (modified after Hairapetian *et al.* 2018), showing the positions of the studied sections (1–12).

tential role in geotourism development (Vujičić *et al.* 2011; Herrera-Franco *et al.* 2022).

While the stratigraphy and paleontology of Central Iran have been widely studied, the geoh heritage significance of Kolah Qazi National Park has not been systematically assessed within a standardized geosite evaluation framework. The park preserves fossil-rich Albian–Turonian sequences, evidence of the Oceanic Anoxic Event, and newly documented cold seep carbonates, representing an important Cretaceous record in Central Iran. This study integrates detailed stratigraphic and paleontological analysis to evaluate its potential for

national geopark designation within the broader context of geotourism and geoconservation.

### Background Information

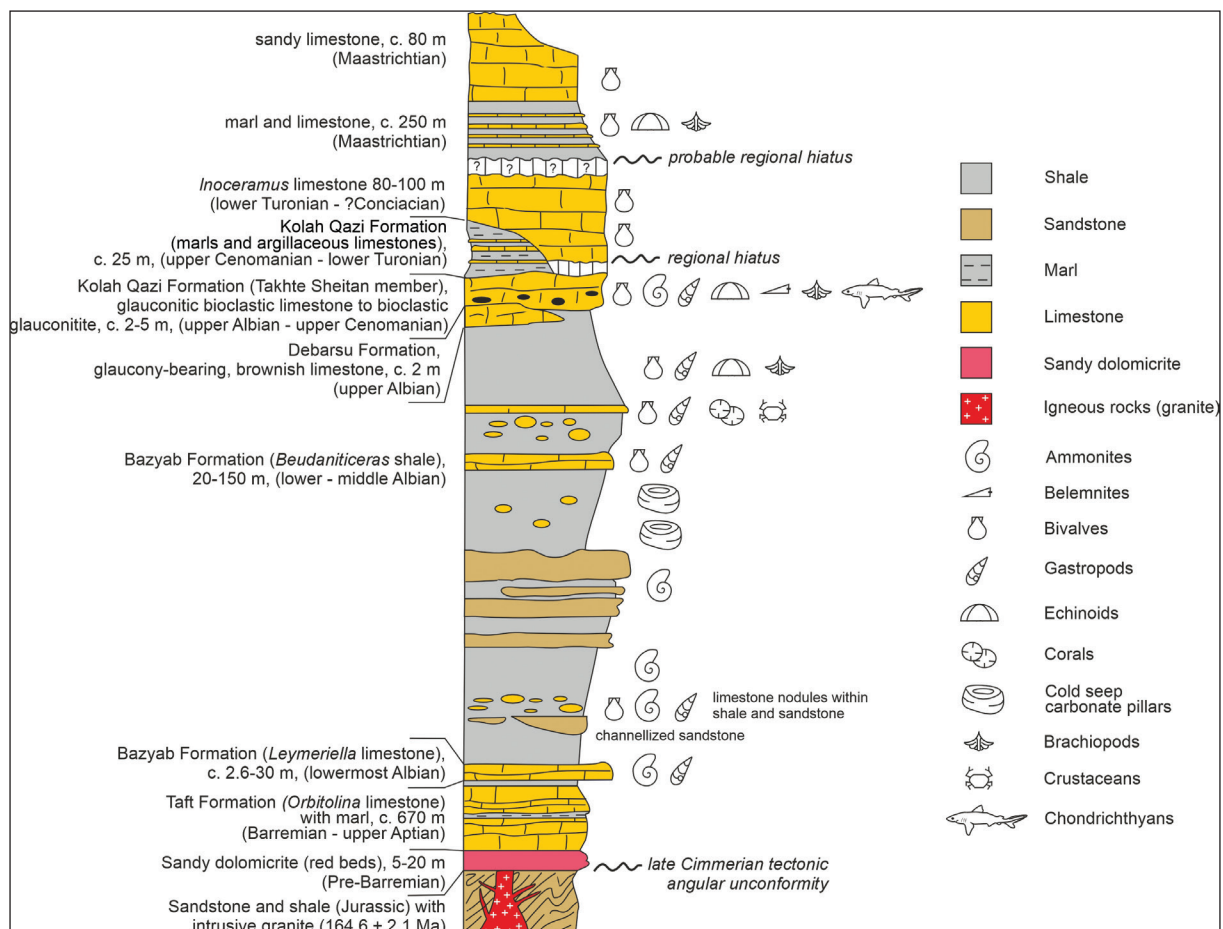
Established in 1967 in southeastern Isfahan Province, Iran, Kolah Qazi National Park features twelve distinct geosites exhibiting deposits from the Middle Jurassic to Late Cretaceous periods.

The region's complex geology includes Late Permian carbonate sediments continuously overlain by Early Triassic carbonates (Zahedi 1976). These are overlain by Early Cretaceous pinkish sandstones and conglomerates, which lie with a major erosional unconformity on a clastic sequence of Early Jurassic sandstone and shale (Stahl 1897). A Late Jurassic granite intrusion cuts through these strata in the Kolah Qazi region. These units are,

in turn, overlain by *Orbitolina* limestone, which displays significant thickness from the Barremian to Upper Aptian.

The base of the Albian stage throughout the Isfahan area is marked by the *Leymeriella* limestone formation, which consists of dark siliceous limestone (Seyed-Emami 1977).

This research highlights the extraordinary fossil-based values and unique stratigraphic features of the geosites within Kolah Qazi National Park. It aims to support the park's recognition as a significant global geoh heritage site by emphasizing its stratigraphic and paleontological importance. Achieving this goal will require further development, comprehensive analysis, and detailed technical surveys.



**Figure 2.** Generalized stratigraphic column of the Kolah Qazi region showing major lithostratigraphic units, age assignments, key fossil horizons, and principal unconformities from the Jurassic to the Maastrichtian.

## Method

We used an integrated approach including library research, field surveys, laboratory analyses for twelve selected geosites in and around Kolah Qazi National Park. All procedures followed established geological and geotourism frameworks (Zahedi 1976; Collinson *et al.* 2006; Lima 2007; Avila *et al.* 2016).

Library-based work provided the geological and stratigraphic context of the Aptian to Maastrichtian succession. Aerial photographs, satellite images, and previous studies were used to identify promising geosites, prepare preliminary geological profiles and maps, and determine suitable fieldwork timing based on regional geomorphology and climate.

Twelve stations were selected based on their lithological diversity, fossil richness, and geomorphological significance. Field surveys included measuring and logging outcrops with minimal surface cover, describing lithologies, and documenting sedimentary structures following Collinson *et al.* (2006). Representative macrofossils and rock samples were collected for petrographic, stratigraphic, and facies analysis. GPS-based coordinates and field photographs supported all observations. Field and laboratory observations were also used to identify key features such as seep carbonates, glauconitic horizons, and diagnostic fos-

sil assemblages.

Laboratory analyses focused on the preparation and study of collected samples. Macrofossils were examined to document diagnostic characteristics.

## Geological Setting

Iran lies at the convergence of several tectonic plates, resulting in a geologically complex terrain. The Esfahan region is situated on the western margin of Central Iran and is associated with other structural units including the nearby Zagros mountains. To the east lies the Central-East Iranian Microcontinent (CEIM), which comprises tectonic blocks such as Lut and Yazd and is separated from northwest Iran by the Great Kavir Fault. Collectively, these structural domains form the Iran Plate, bounded by the Paleo-Tethyan suture to the north and the Neo-Tethyan suture to the south (Takin 1972; Hairapetian *et al.* 2018).

Kolah Qazi National Park is located on the southeastern outskirts of Isfahan Province, adjacent to the city of Baharestan. It spans approximately 50,911 hectares, with geographical coordinates between longitudes 51°41'57"E to 52°08'09"E and latitudes 32°15'33"N to 32°28'20"N. The park has an average elevation of 1,720 meters above sea level.

Within the park, twelve geosites offer distinct geomorphological and geological features of sig-



**Figure 3.** Overview of Station 1 showing Albian to Turonian deposits in the Lashotor mining area section.



**Figure 4.** General view of the outcrop showing pillar-like carbonate structures (A), along with selected close-up views (B-F) illustrating the morphological diversity of these decimeter-scale structures (scale bar = 10 cm).

nificant scientific, educational, and geotourism values.

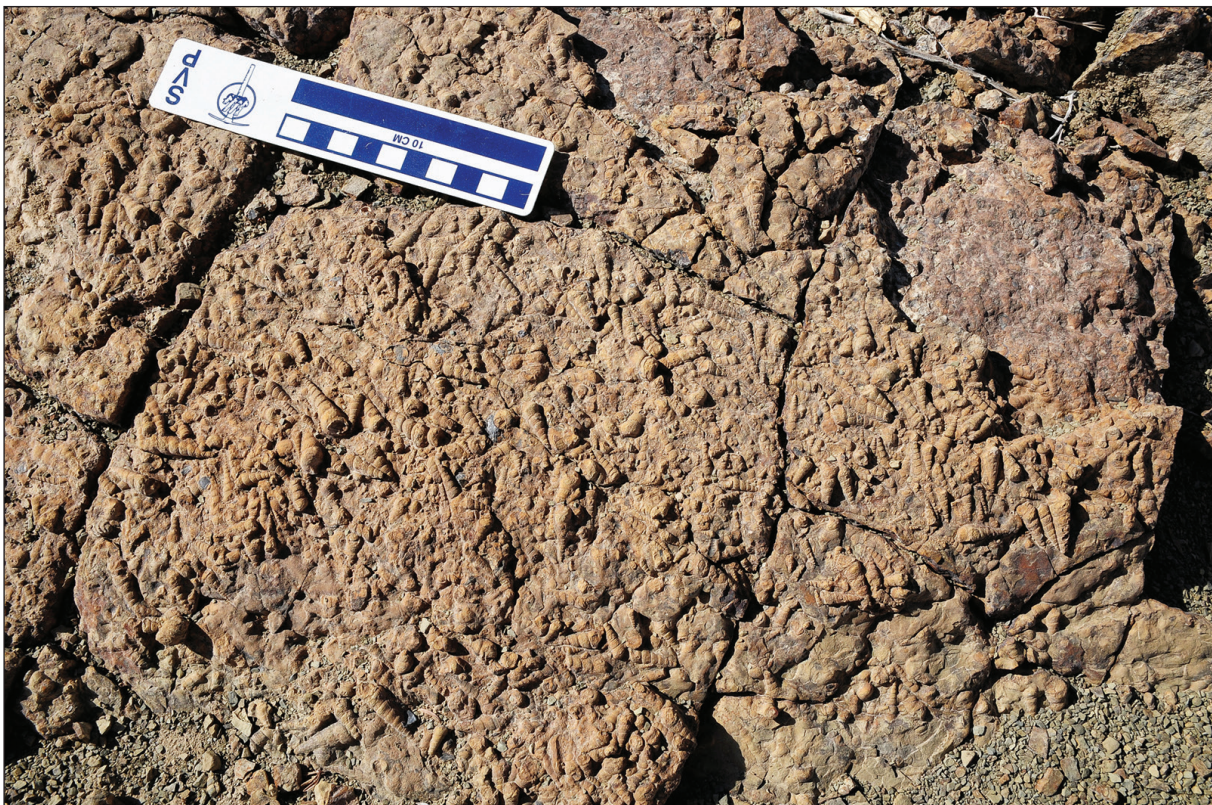
#### **Station 1: Lashotor Mining Area Outcrop**

This geosite, located in the Lashotor mineral zone, is distinguished by the first documented occurrence

in Iran of cold seep carbonates within the *Beudanticeras* shale unit. Seep carbonates form through the microbial anaerobic oxidation of methane and hydrogen sulfide in fluid-rich ecosystems, leaving distinctive geochemical, structural, and biological signatures (Campbell and Bottjer 1995; de Ronde



**Figure 5.** Close-up view of nodular structures at the base of Albian deposits, Lashotor mining area section.



**Figure 6.** Close-up view of limestone horizons containing abundant gastropod assemblages in the Albian deposits, Lashotor mining area section.

and Ebbesen 1996). This study reports, for the first time in Iran, the identification of decimeter-scale, pillar-like carbonate structures within the *Beudanticeras* shale unit. These cold seep carbonates are characterized by low-diversity fossil assemblages and nodular morphologies. Field evidence indicates they formed due to syn-depositional fluid migration along active faults.

This geosite features upper Albian to lower Turonian sedimentary exposures. The sequence includes olive-green shale rich in ammonites (*Beudanticeras* spp., *Douvilleiceras mammillatum*), gastropods, and bivalves (Seyed-Emami *et al.* 1971; Seyed-Emami and Wilmsen 2016). The basal layers contain nodules that preserve mollusks in exceptional detail. A distinct glauconitic limestone layer marks the transition from the upper Albian to the Cenomanian.

While the Albian deposits are highly fossiliferous, they are dominated by ammonites, gastropods, and bivalves, with coral fossils being relatively

rare. Several species of ammonites and gastropods have been identified from this shale unit, alongside fewer species of bivalves, corals, and crustaceans (Seyed-Emami and Immel 1996; Yazdi *et al.* 2011).

### Station 2: Mazra'eh Section Outcrop (Orbitolinid-Bearing Limestone)

This station was selected because it exposes a well-preserved, thick orbitolinid-bearing carbonate succession that provides strong biostratigraphic control for the Early Cretaceous in the study area. This unit consists of thick-bedded to massive, gray to brown limestone with interbedded dolomitic layers, rich in benthic foraminifera such as orbitolinids and rudists. Its average thickness in the mapped area is approximately 300 m. Thin-section analysis reveals key biostratigraphic species, including *Palorbitolina lenticularis* at the base and *Mesorbitolina* cf. *texana* at the top. These findings indicate an upper Barremian to upper Aptian age, based on updated orbitolinid



**Figure 7.** General view of Station 2 showing the outcrop of orbitolinid-bearing limestones in the Mazra'eh section.

taxonomy and Early Cretaceous biostratigraphy (Simmons *et al.* 2000; Schroeder *et al.* 2010).

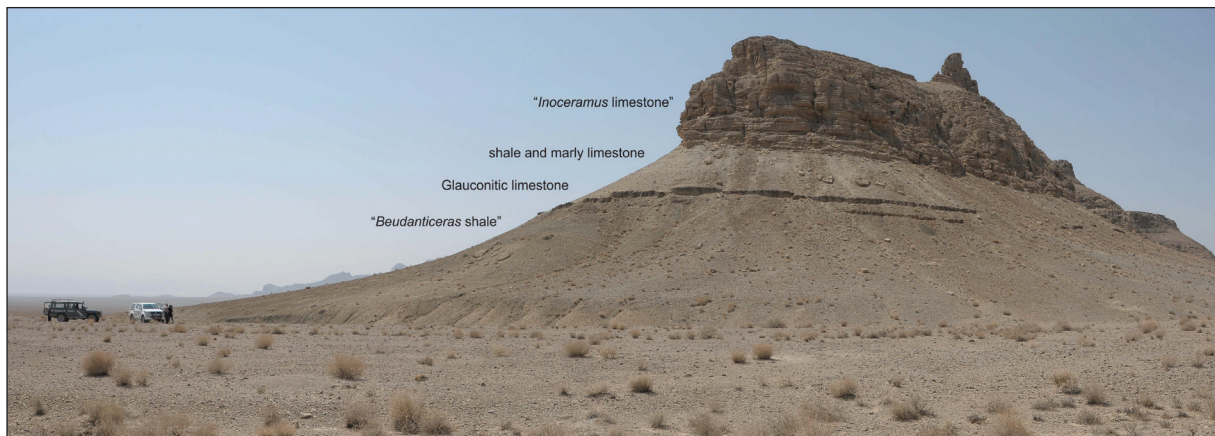
### Station 3: Takhte Sheitan Rock Section (Albian to Turonian Sediments)

The Takhte Sheitan Rock Section exposes a thin glauconitic unit that records significant reworking across a major stratigraphic unconformity. This unit reaches a maximum thickness of about 5 m and lies unconformably above *Beudanticeras*-bearing shales. It is composed of pale argillaceous limestone interbedded with dark, resistant, glauconitic and locally conglomeratic layers.

Although the unit contains abundant ammonites spanning upper Albian to middle Cenomanian

ages, these fossils are not preserved in situ. The glauconitic conglomerate represents a middle–upper Cenomanian deposit that incorporates reworked older ammonites (Hairapetian *et al.* 2018). Consequently, this interval does not preserve a continuous Albian to Cenomanian biostratigraphic succession. The glauconitic unit previously attributed to the Debarsu Formation is reinterpreted as the basal Takhte Sheitan Member of the Kolah Qazi Formation, deposited above a major unconformity.

Paleontological investigations have documented an exceptionally diverse ammonite assemblage (Seyed-Emami 1977, 1982; Kennedy *et al.* 1979; Immel and Seyed-Emami 1985). This study



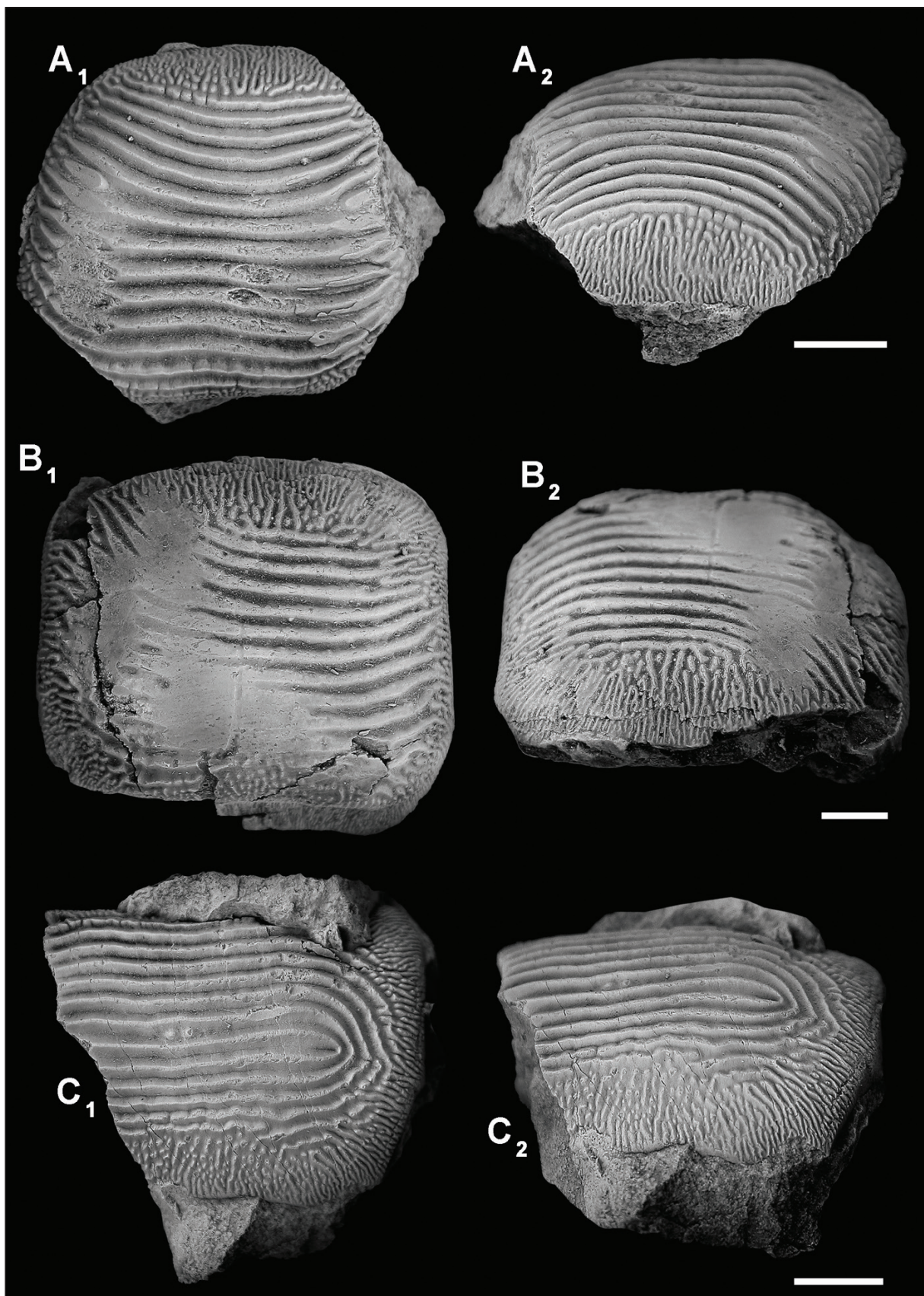
**Figure 8.** Overview of Station 3, showing Albian to Turonian deposits in the Takhte Sheitan Rock section.



**Figure 9.** Posterior view of the ammonite species *Sharpeiceras laticlavium* from the Takhte Sheitan section.

re-evaluates all previously reported taxa and introduces several newly identified species. In total, 97 fossil taxa were identified, representing one of the most diverse Cretaceous ammonite assemblages reported from the region. The complete taxonomic list and literature sources are provided in Supplementary Table S1.

The overlying marls and argillaceous limestones of the Kolah Qazi Formation at this type section record Oceanic Anoxic Event 2 (OAE 2), as demonstrated by high-resolution  $\delta^{13}\text{C}$  data showing a pronounced positive carbon isotope excursion that correlates with global reference curves and reflects increased organic carbon burial during



**Figure 10.** Dental plates of the shark species *Ptychodus decurrens* shown in occlusal views (A1, B1, C1) and labial views (A2, B2, C2). Scale bars equal 5 mm.

upper Cenomanian–lower Turonian marine deepening (Hairapetian *et al.* 2018).

Three shark dental plate (shell-crushing teeth) specimens were recovered from the base of the glauconitic limestone unit in Kolah Qazi. Two specimens were confidently identified as *Ptychodus decurrens*, dating from the middle/upper Albian to the Turonian. This identification is based on their square cross-section, low crowns with parallel ridges, and densely packed, enamel-folded marginal features. The third, partially preserved specimen exhibits a rectangular crown with 14 concentric ridges, showing subtle morphological differences from the other two.

This discovery is significant, as it represents the oldest confirmed record of the species in Asia and its easternmost known occurrence in Laurasia, substantially expanding its known paleobiogeographic range (Meyer 1974; Siverson 1999).

#### **Station 4: Sheidan Mountain Section (Upper Cretaceous Sediments)**

One of the best exposed Maastrichtian marine successions in the Kolah Qazi area is preserved in the highlands of Sheidan Mountain, where the youngest Cretaceous deposits comprise approximately 250 m of alternating gray and brown marl and limestone. This sequence is conformably overlain by a rudist-bearing limestone unit that lacks age-diagnostic index fossils. Field investigations and thin-section analyses revealed no evidence of a stratigraphic discontinuity at the contact between these units. Consequently, the underlying marl and limestone sequence is assigned a Maastrichtian age based on its stratigraphic position (Habibi *et al.* 2006).

#### **Stations 5–8: Qarneh Mountain Area Outcrops (Albian to Turonian Sediments)**

Excellent outcrops are exposed along the eastern Qarneh Mountains (Stations 5–8), showing pronounced lateral variation within the glauconitic



**Figure 11.** General view of the outcrop at Station 4, displaying Upper Cretaceous deposits in the Sheidan Mountain section.



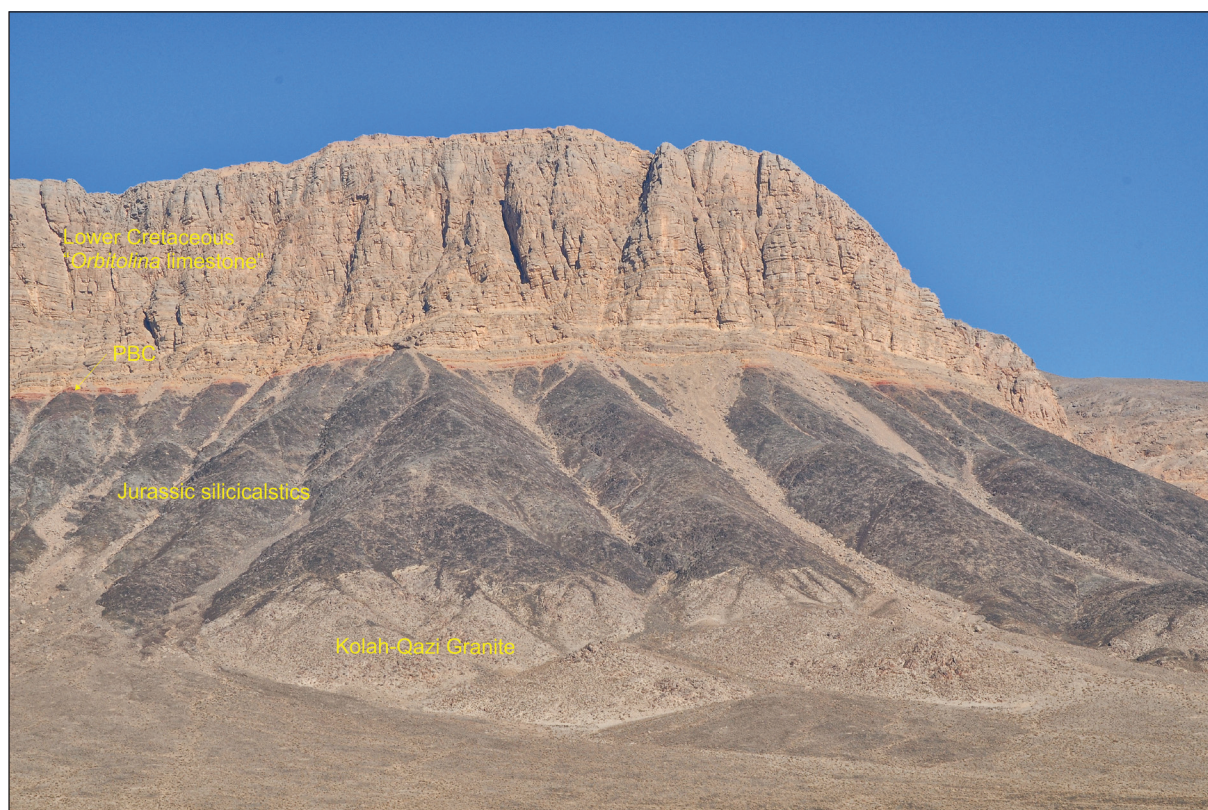
**Figure 12.** Close-up view of the upper limestone and main glauconitic conglomerate horizon at Station 5, Qarneh Mountains area.



**Figure 13.** General view of Station 9 showing the basal Lower Cretaceous deposits, consisting of red sandy micritic dolomite and brick-colored dolomite, overlying dark-colored deposits of the Early to Middle Jurassic in the southeastern Kolah Qazi section.

horizon and its overlying units. The glauconitic layer is highly condensed and thins to approximately 20 cm at Stations 5 and 6, reflecting stronger condensation and erosion at these sites, whereas it thickens to about 2 m at Stations 7 and 8 through

local accumulation of reworked material rather than increased stratigraphic completeness. Field and petrographic evidence, including rounded nodules, phosphatized fossils, and multiple generations of glauconite, indicates repeated phases of erosion,



**Figure 14.** Outcrop view of the angular unconformity between Jurassic and Lower Cretaceous strata at Station 10.

condensation, and sediment reworking. In this context, glauconite is significant as an indicator of low sedimentation rates associated with marine transgression and stratigraphic condensation on a shallow shelf, marking hiatuses and reworking surfaces rather than continuous deposition. The unit consists of glauconite-rich limestones and transgressive conglomerates deposited in a shallow, high-energy setting. Available age constraints indicate a middle to upper Cenomanian age for these deposits (Hairapetian *et al.* 2018).

#### **Station 9: Southeast Kolah Qazi Section (Basal Lower Cretaceous Deposits)**

In the Isfahan region, the Cretaceous sequence typically begins with a unit of pink basal conglomerate and red sandstone. While this unit is only a few meters thick in the south and southeast, it thickens to approximately 400 m near Zefreh in the northeast. It rests unconformably on Early to Middle Jurassic sandstone and shale or, in some

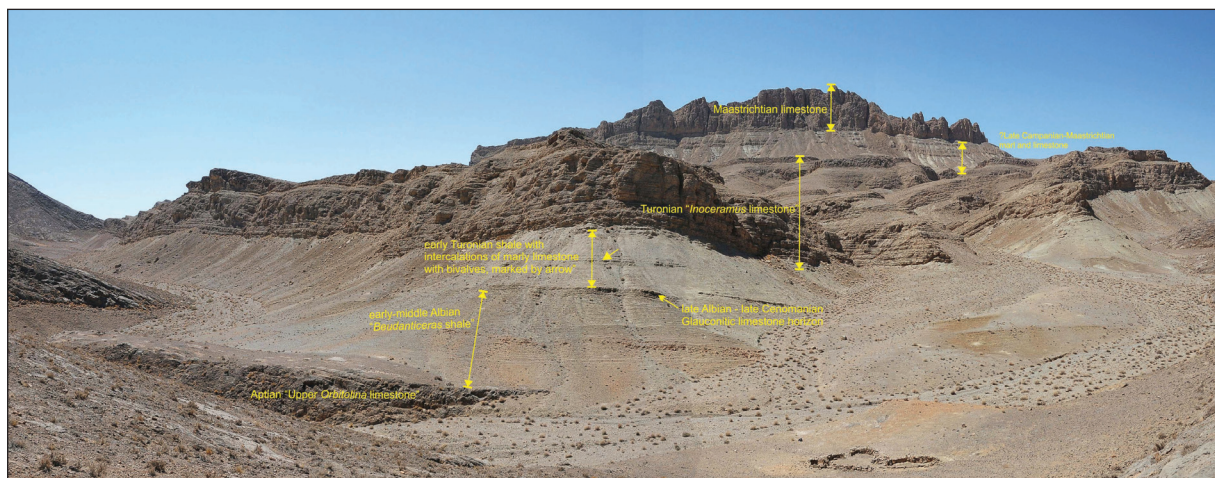
areas, on the intrusive granodiorite of Kolah Qazi. Within the national park, the base of the unit is marked by a distinctive 2.5-m layer of red sandy micritic dolomite and brick-colored dolomite. This unique facies indicates a southeastward-sloping sedimentary basin during the onset of Cretaceous deposition.

#### **Station 10: Southeastern Kolah Qazi Section (Angular Unconformity)**

The Southeastern Kolah Qazi Section preserves a classic example of an angular unconformity, making it a key site for documenting regional tectonic events. This section exhibits a prominent angular unconformity, with a dip of approximately 30 degrees, separating Jurassic strata from overlying Lower Cretaceous deposits. This large-scale unconformity records significant tectonic activity linked to the Late Cimmerian orogenic event, which is well-documented across the central and eastern Iranian microcontinent and the Sanandaj–



**Figure 15.** Broad landscape view of Station 11 showing the igneous–sedimentary unconformity between the Kolah Qazi granite and the Lower Cretaceous deposits in the southeastern Kolah Qazi section.



**Figure 16.** General outcrop view of Station 12 showing Aptian to probable Maastrichtian deposits in the Gholleh-Khorshid Mountain section.

Sirjan Zone (Fürsich *et al.* 2009; Wilmsen *et al.* 2009, 2010, 2015). These tectonic episodes are attributed to the closure of oceanic basins surrounding the Central Iran blocks. In the Kolah Qazi National Park, the unconformity surface is directly overlain by a distinctive layer of reddish sandy dolomicrite.

### Station 11: Igneous–Sedimentary Unconformity (Kolah Qazi Granite and Lower Cretaceous Deposits)

This section is significant because it clearly exposes both the Kolah Qazi granite and the stratigraphic unconformity where Lower Cretaceous sediments rest directly on the igneous body, giving it high geotouristic and educational val-

ue (Chiu *et al.* 2013). The Kolah Qazi igneous intrusion, located within the Sanandaj–Sirjan Zone, is composed primarily of monzogranite, granodiorite, and syenogranite. It contains mafic microgranular enclaves rich in plagioclase and biotite, as well as aluminous enclaves with cordierite, spinel, and garnet, indicating an S-type granite origin (Ahmadian *et al.* 2018). The intrusion cuts through Jurassic shales and sandstones, forming a distinct metamorphic aureole. Radiometric dating constrains the intrusion age to  $164 \pm 1.2$  Ma (Callovian). In the southeastern section of the park, Lower Cretaceous sediments lie unconformably upon this granite, creating a clear igneous–sedimentary contact.

#### **Station 12: Gholleh-Khorshid Section (Aptian to Maastrichtian Sedimentary Sequence)**

The Gholleh-Khorshid section, located south of Kolah Qazi National Park and first mapped by (Zahedi 1976), represents one of the area's most notable outcrops. Its significance lies in a continuous stratigraphic succession spanning from the upper Aptian (*Orbitolina*-rich limestones) to what are likely the region's Maastrichtian deposits. This section provides an exceptional record of key transitions, such as the shift from *Orbitolina* limestones to *Beudanticeras*-bearing shales which are often obscured by erosion or faulting elsewhere in the park. As the most complete Cretaceous record in the area, the Gholleh-Khorshid section is characterized by notable variations in the thickness and exposure of its Campanian strata.

### **Results**

The integrated evaluation of twelve geosites in Kolah Qazi National Park documents a stratigraphic record spanning the Barremian to likely Maastrichtian, with distinct fossil assemblages, lateral facies variations, and major unconformities.

## **Stratigraphic Successions and Fossil**

### **Assemblages**

The most fossiliferous units are concentrated in the Albian to Turonian interval. At Station 1 (Lashotor Mining Area), the Albian sequence comprises olive-green shale rich in ammonites, gastropods, and bivalves, with nodules preserving exceptional mollusk detail (Figs. 5, 6). A distinct glauconitic limestone layer marks the Albian-Cenomanian transition.

Station 3 (Takhte Sheitan Rock Section) exposes the thickest (~5 m) development of this fossil-rich interval. It consists of alternating pale argillaceous limestone and dark glauconitic conglomeratic layers, hosting an exceptionally diverse ammonite assemblage. Our re-evaluation confirms over 97 ammonite taxa (Supplementary Table S1), spanning the upper Albian to upper Cenomanian. This assemblage is among the most diverse known globally.

Station 2 (Mazra'eh Section) exposes the older, Barremian–Aptian orbitolinid-bearing limestone, approximately 300 m thick. Thin-section analysis confirms key biostratigraphic markers: *Palorbitolina lenticularis* at the base and *Mesorbitolina cf. texana* at the top.

The youngest Cretaceous deposits are at Station 4 (Sheidan Mountain Section), comprising ~250 m of alternating gray and brown marl and limestone, conformably overlain by a rudist-bearing limestone, and assigned a Maastrichtian age based on stratigraphic position.

### **Lateral Facies Variations and Unconformities**

Significant lateral variation is evident in the Qarneh Mountains area (Stations 5–8). Here, the glauconitic horizon thins to ~20 cm at Stations 5–6 but thickens to ~2 m at Stations 7–8 (Fig. 12). Sedimentological evidence (rounded nod-

ules, phosphatized fossils) indicates erosion and reworking in a shallow, high-energy environment, suggesting an upper Cenomanian–lower Turonian age, slightly younger than previous ammonite-based datings.

Key regional unconformities are well-exposed. Station 9 shows the basal Lower Cretaceous unit, marked by a unique 2.5 m layer of red sandy micritic dolomite, indicating a southeastward-sloping paleobasin. Station 10 displays a prominent angular unconformity (~30° dip) separating Jurassic from Lower Cretaceous strata, recording Late Cimmerian tectonic activity. Station 11 features an igneous–sedimentary unconformity where Lower Cretaceous sediments lie directly upon the Callovian-aged (~164 Ma) Kolah Qazi granite. igneous–sedimentary unconformity where Lower Cretaceous sediments lie directly upon the Callovian-aged (~164 Ma) Kolah Qazi granite.

Station 12 (Gholleh-Khorshid Section) provides the most complete Cretaceous record in the area, with a continuous succession from upper Aptian orbitolinid limestones to probable Maastrichtian deposits, capturing key transitions often obscured elsewhere.

### Novel Discoveries

This study reports several first-time findings that enhance the scientific value of the park:

1. Mesozoic Seep Carbonates: At Station 1, decimeter-scale, pillar-like carbonate structures were identified within the *Beudanticeras* shale unit (Fig. 4). These exhibit low-diversity fossil assemblages and nodular morphologies characteristic of cold seep environments, formed by syn-depositional fluid migration. This constitutes the first reported occurrence of Mesozoic seep carbonates in Iran.
2. Shark Dental Plates: From the glauconitic

limestone at Station 3, three shark dental plates were recovered. Two are confidently assigned to *Ptychodus decurrens* (Fig. 10). This represents the oldest confirmed Asian record and easternmost Laurasian occurrence of *P. decurrens*, significantly expanding its known paleobiogeographic range.

3. Detailed reanalysis of the glauconitic interval, following the age framework of Hairapetian *et al.* (2018), demonstrates that the previously defined glauconitic limestone records multiple stratigraphic components separated by a major erosional unconformity. The lower glaucony bearing limestone corresponds to a remnant of the Debarsu Formation and is constrained to the middle to upper Albian based on foraminifera and underlying ammonite assemblages. This unit is erosionally overlain by the Takhte Sheitan Member, a condensed transgressive lag deposit composed of glauconitic limestone/conglomerate, whose matrix yields a mid to upper Cenomanian age and is associated with the initial phase of OAE 2, while the abundant phosphatized ammonites and inoceramid bivalves represent reworked material derived from upper Albian to middle Cenomanian strata. The overlying marls and argillaceous limestones of the Kolah Qazi Formation record continued deposition during the upper Cenomanian and document the Cenomanian to Turonian boundary interval, with the lower part of the overlying *Inoceramus* Limestone indicating a lower Turonian age.

### Discussion

The integrated stratigraphic and geosite assessment demonstrates that Kolah Qazi National Park preserves a scientifically significant Cretaceous record in Central Iran. Three sites stand out with national or international significance due to their

rare and complete geological records. The Albian–Turonian successions at Lashotor and Takhte Sheitan, along with the Upper Cretaceous section at Sheidan Mountain, provide exceptional records of Mid to Late Cretaceous environments in Central Iran. Their rich fossil content, well-preserved sedimentary structures, and continuous stratigraphy make them invaluable for research, education, and geotourism. The discoveries of Mesozoic cold seep carbonates at Lashotor and the oldest Asian occurrence of *Ptychodus decurrens* at Takhte Sheitan further elevate the global importance of these sites.

Although the remaining geosites scored at a regional or local level, they contribute meaningfully to the geological narrative. The Barremian–Aptian orbitolinid limestones of Mazra'eh, the lateral facies changes in the Qarneh Mountain outcrops, and the well-defined angular and igneous–sedimentary unconformities illustrate key aspects of the area's stratigraphic and tectonic evolution. Their scores primarily reflect practical limitations such as accessibility and existing research infrastructure, rather than a lack of inherent scientific value.

These patterns align with geosite studies worldwide, where top-ranked sites typically combine rarity, good preservation, clear scientific relevance, and educational potential. The Kolah Qazi results reinforce this trend and validate the applied methodology.

The findings also reveal opportunities for geotourism development. Sites such as Takhte Sheitan, Lashotor, the angular unconformity, and the continuous Cretaceous succession at Gholleh-Khorshid could anchor interpretive trails or educational field stops. With modest improvements in access and protection, they could become key resources for balanced tourism development.

Concurrently, the study highlights the need for

enhanced conservation. Some geosites, particularly near historical mining areas, show signs of disturbance or vulnerability to erosion and fossil collecting. The sensitive seep-carbonate horizon at Lashotor and the ammonite-rich units at Takhte Sheitan warrant targeted monitoring and protective measures.

Overall, the Kolah Qazi region offers a rich combination of geological heritage, paleontological diversity, and educational potential. With thoughtful management, these geosites can support both cutting-edge research and viable geotourism, securing their value as natural assets for future generations.

### Conclusion

This study demonstrates that the geosites of Kolah Qazi National Park and its surroundings hold considerable scientific and geotourism value. Among the twelve evaluated sites, three exhibit national or international significance due to their rare geological features, rich fossil assemblages, and well-preserved stratigraphy. The remaining sites, while ranked at regional or local levels, provide important insights into the geological evolution of Central Iran and offer meaningful educational opportunities.

The results underscore the potential for developing a structured geotourism network in the region, particularly around sites showcasing exceptional fossils, clear unconformities, and continuous Cretaceous stratigraphy. Several sites also require improved protection against erosion, unauthorized collecting, and human disturbance. Implementing conservation measures and enhancing responsible visitor access would support the sustainable use of these natural resources.

In summary, the findings confirm Kolah Qazi's importance as a natural archive of geological history and support the park's suitability for struc-

tured geotourism development while underscoring the need for targeted conservation strategies to protect vulnerable fossiliferous and stratigraphic horizons. Kolah Qazi therefore represents a significant geological archive in Central Iran and a strong candidate for future geopark recognition.

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### Conflict of Interest

The author declares no conflict of interest.

### Author's

Ziba Shojaei conceived the study, conducted the research, analyzed the data, and wrote the manuscript.

### Contribution:

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