

GEOTOURISM GUIDE

# Geotourism Attractions of Northern Oman



## Title:

Geotourist Guidebook. Geotourism Attractions of Northern Oman.

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## Funding:

This publication was prepared as the part of the project "Excellence Initiative – Research University (IDUB)" carried out at the AGH University of Krakow under Action 12: "Integration of the educational process with scientific research".

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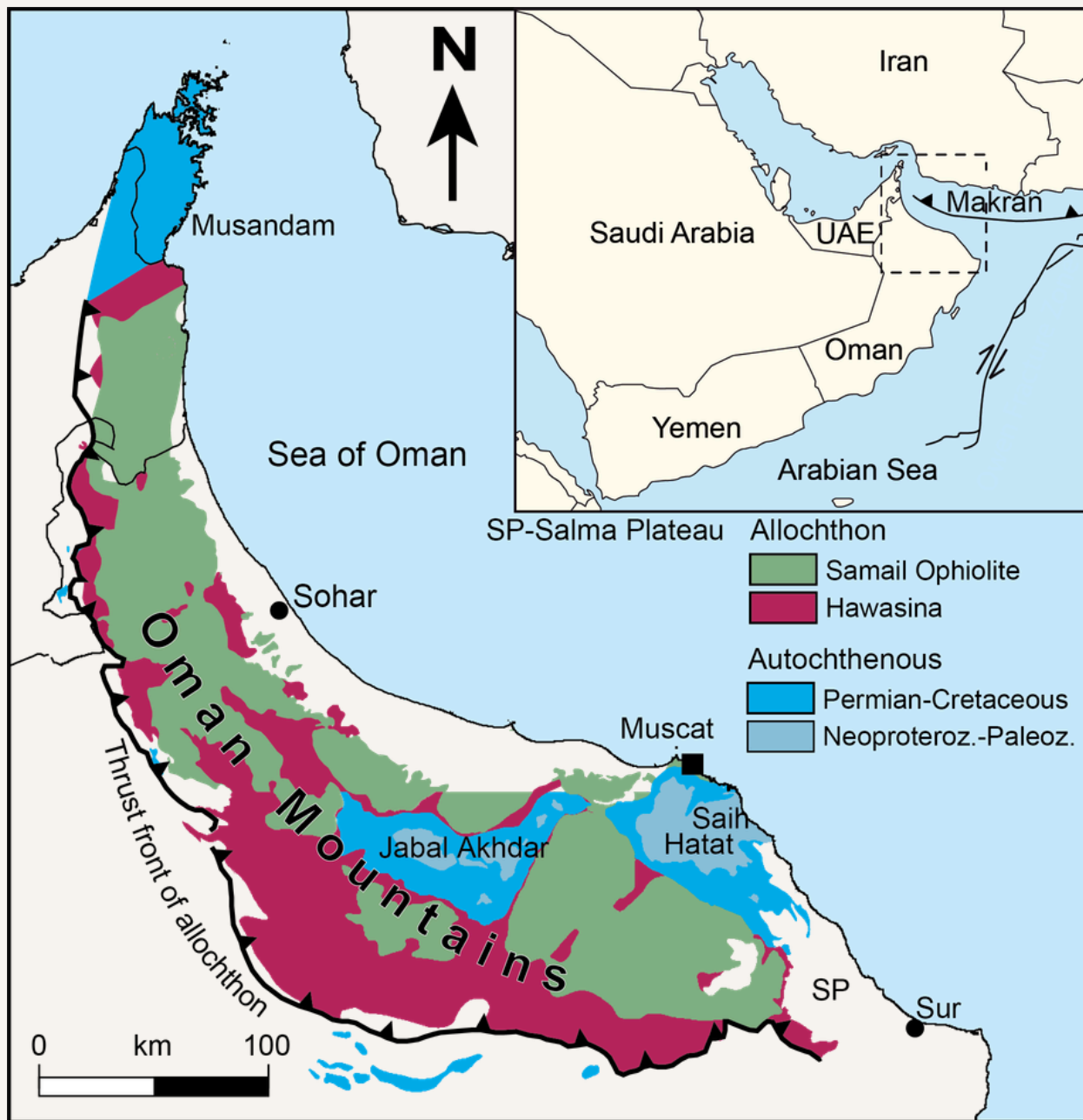
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# Location of attractions

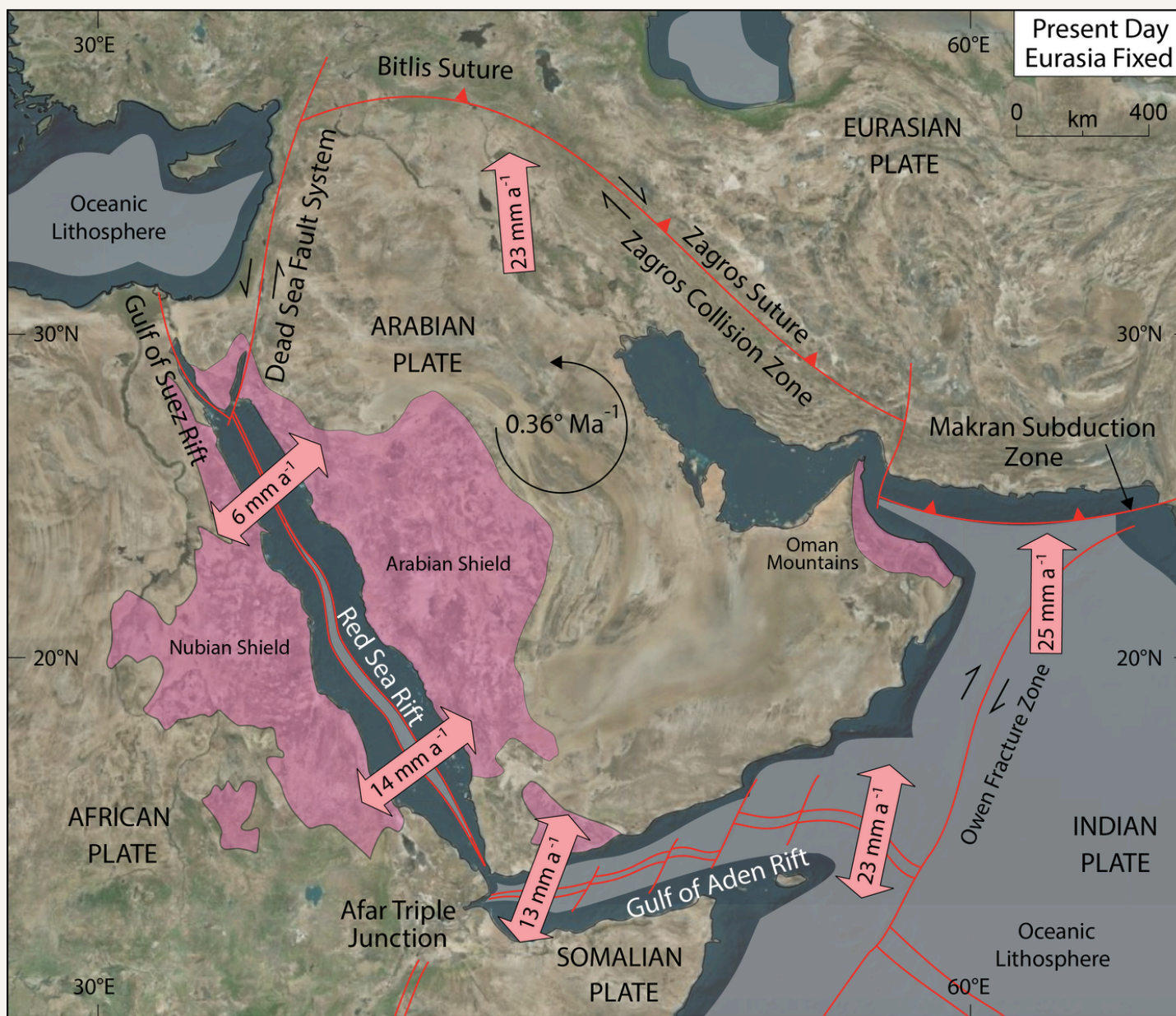


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# Geological map of northern Oman



Geological overview map of the Oman Mountains (modified after Forbes et al., 2010; Callegari et al., 2022)



Present-day Arabian Plate with its plate boundaries and the mean anticlockwise rotation of the Arabian Plate ( $0.36^\circ$  per million years) after Scharf et al. (2025).

# Practical Information

## BEST TIME TO TRAVEL

The most comfortable period for visiting Oman is October to April, when daytime temperatures range from 20–30°C.

Summer (May–September) is extremely hot, especially in the interior, with temperatures exceeding 45°C.

## WEATHER, CLIMATE

Oman has a dry desert climate with strong regional contrasts.

- Mountains: cooler, especially Jebel Shams and Jebel Akhdar.
- Coast: humid, warm winds.
- Dhofar region: influenced by the monsoon (khareef) from June to September.

## SAFETY, INFRASTRUCTURE

Oman is considered one of the safest countries for travelers, including solo female travelers.

Roads are modern and well-maintained; however, for mountain or desert areas, a 4WD is required. Public transport is limited – renting a car is the most convenient option.

## CULTURE, BEHAVIOUR

Omanis are known for their hospitality, politeness, and calm demeanor.

- Dress modestly, especially in villages and mosques.
- Avoid loud behaviour and showing affection in public.
- Always ask before photographing people.

## RELIGION, WEEKDAY

Islam shapes daily life in Oman. The weekend falls on Friday and Saturday. Shops may close during prayer times in smaller towns.

## DURING RAMADAN

Ramadan is a remarkable time to visit, but visitors should be mindful:

- No eating, drinking, or smoking in public during daylight.
- Restaurants open after sunset.
- Tourist sites may operate on reduced hours.

## WATER, NATURE

Tap water is generally safe in cities, but bottled water is recommended for travel.

When visiting natural sites – wadis, deserts, mountains – follow Leave No Trace principles.

## DRIVING TIPS

- 4WD required for: mountain tracks, wadis, desert routes.
- Strict speed limits; fines are automated.
- Avoid driving at night outside towns (camels on the road!).

## FINAL TIPS

Oman is one of the most welcoming and peaceful countries in the region. Respect for local culture, nature, and traditions ensures a meaningful and safe travel experience.

# Oman

## BETWEEN GEOLOGY, CLIMATE AND SUSTAINABLE TOURISM

Oman, located at the southeastern tip of the Arabian Peninsula, is a land where remarkable geological features, unique climatic conditions, and a centuries-old tradition of living in harmony with a harsh desert environment come together. It is a country of contrasts – from the monumental Al-Hajar Mountains (Oman Mountains), through deep canyons and dry wadi valleys, to vast deserts and tropical shores of the Indian Ocean. This diversity of landscapes offers not only unforgettable visual impressions but also a striking record of almost 900 million years of Earth's geological history and a living example of contemporary challenges driven by climate change.

The aim of this guide is to present selected attractions of Oman from a geotourism and ecotourism perspective. Geotourism encourages conscious exploration of the processes and phenomena that shape our planet while deepening our understanding of the connections between the lithosphere, hydrosphere, atmosphere, and biosphere. In Oman, special attention is drawn to the Samail Ophiolite – the world's best-preserved and largest sequence of oceanic lithosphere exposed on land – and the aflaj irrigation systems, inscribed on the UNESCO World Heritage List, which exemplify sustainable water management practices that have endured for millennia.

Yet, Oman is also a country already facing the consequences of global climate change: extreme heat, increasingly frequent tropical cyclones, rising sea levels. These phenomena pose challenges both for local communities and for the growing tourism industry. In this context, the guide seeks not only to showcase the beauty of Oman's natural – particularly geological – and cultural heritage but also to highlight pathways for responsible travel that can serve as tools for environmental protection and ecological awareness.

We invite you on a journey through Oman – a land where geology intertwines with culture, and nature with everyday life. This guide combines science with the passion for discovery and inspires reflection on how to travel wisely and with respect for our planet.



*Trail to the Tahery cave*

CHAPTER 1

# Ophiolite sequence



# What is an ophiolite?

An ophiolite is a fragment of former oceanic lithosphere that has been uplifted onto the Earth's surface through the process of obduction. Its most important component consists of ultramafic rocks of the upper mantle, collectively referred to as peridotites. In the Samail Ophiolite, peridotites are represented by harzburgites and dunites.

Some of the peridotites underwent secondary hydrothermal alteration caused by hot aqueous fluids. This process is known as serpentinization, and its product is serpentinite. Serpentinites are metamorphic rocks characterized by a distinctive green color and a mottled, veined pattern that resembles snakeskin. It is from these rocks that the ophiolite derives its name. The term "ophiolite" comes from the Greek words ophis meaning snake and lithos meaning stone.

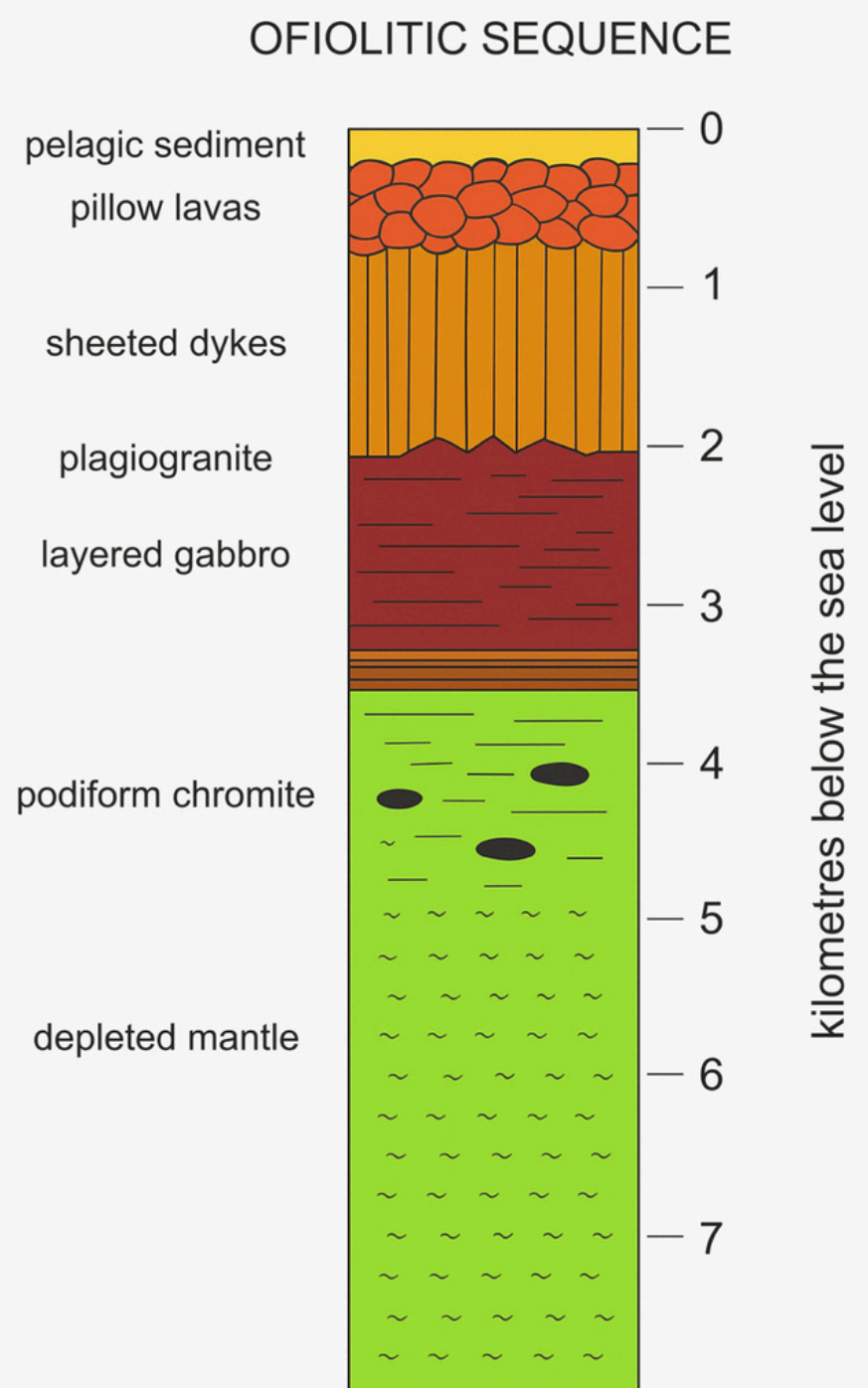
It should be emphasized, however, that serpentinites are products of the alteration of peridotites and not their original equivalent.

Ophiolites are characterized by a distinct and well-defined sequence. At the base of the sequence lie the previously mentioned peridotites. Within the peridotites, there are also interlayers of other upper mantle rocks, including chromitites and pyroxenites, which occur locally as lens-shaped bodies related to magmatic processes.

Above them occur layered ultramafic rocks, followed successively by layered and massive gabbros – coarse-grained intrusive rocks.

Higher up in the sequence is a system of vertical sheeted dolerite (diabase) dike complexes, which pass upward into very characteristic and easily recognizable pillow basalts. These form when lava erupts onto the seafloor, where contact with cold seawater and the influence of high hydrostatic pressure prevent it from flowing freely.

The sequence is capped by deep-marine sediments deposited on the ocean floor, such as radiolarites, clay shales, and pelagic limestones.



*Idealised model of ofiolitic sequence  
(after Condie i Stern, 2023).*

## SOURCES:

- Golonka, J., Słomka, T., Waśkowska, A. (2022). Geologia. Ziemia i procesy endogeniczne. Wydawnictwo AGH.  
 Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.  
 Dilek, Y., & Furnes, H. (2014). Ophiolites and their origins. Elements, 10(2), 93–100.

# Why are ophiolites so special?

Ophiolites, which today can be observed only sporadically where they are exposed on land, reached their present position through obduction – the process in which oceanic lithosphere is thrust over continental crust. This phenomenon is the opposite of subduction, a far more common tectonic process in which the dense oceanic plate is pulled or pushed beneath the buoyant continental another. Under typical circumstances, oceanic lithosphere descends into subduction zones and brought is into the deep mantle, which is why the rare occurrences of ophiolites are so exceptional and valuable to scientists. They most commonly occur as small, strongly deformed fragments in collisional orogens, where they became trapped between continental rocks. This happens as a result of the compression of oceanic lithosphere during the collision of two continents. The exposures visible today formed through later erosion, and their primary structure is often disrupted by deformation.

The largest ophiolite is located in Oman – The Samail Ophiolite (named after its type locality Samail) – stands out among ophiolites worldwide. Its structure has remained relatively well preserved because the mountain belt was not affected by continent-continent collision, allowing direct study of ancient oceanic lithosphere. This is a major advantage, as investigating non-obducted rocks at great depths beneath the ocean is extremely challenging; so far, only about one-third of the average thickness of oceanic lithosphere has been drilled. Unlike other ophiolite complexes, the Samail Ophiolite does not records continental collision and thus, provides valuable insights into reconstructing obduction processes. Ophiolites represent unique relics of vanished oceans lithosphere.

The Samail Ophiolite is exposed in the northeastern part of the country, forming a belt approximately 500 km long, 50–100 km wide, and up to 15 km thick. The igneous rocks that make up this complex formed from during the Late Cretaceous (Cenomanian). At that time, the Arabian Plate, on which Oman lies today, began moving toward the Eurasian Plate, which lies within present-day Iran. Initially, the Neotethys Ocean was subducted beneath the Eurasian Plate, but during the Cretaceous this process was replaced by obduction, when fragments of oceanic crust were thrust over the continental margin. Today, large remnants of this former oceanic lithosphere can be observed along the edge of the Arabian Plate from Turkey to Oman. However, only in Oman the ophiolite is unaffected by continent-continent collision as for i.e., Iran with the Zagros Mountain Belt.



## SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). *Field Guide to the Geology of Northeastern Oman*. Borntraeger Science Publishers.

Golonka, J., Słomka, T., Waškowska, A. (2022). *Geologia. Ziemia i procesy endogeniczne*. Wydawnictwo AGH.

Dilek, Y., & Furnes, H. (2014). Ophiolites and their origins. *Elements*, 10(2), 93–100. <https://doi.org/10.2113/gselements.10.2.93>

LOCATION: 23.4437531N, 57.6567686E



4WD REQUIRED

# Moho Discontinuity

VISUAL APPEAL:



SCIENTIFIC VALUE:



A discontinuity is a boundary within the Earth that separates layers with different densities and seismic wave velocities. It typically takes the form of a zone in which wave velocities change abruptly. The shallowest and best-known discontinuity is the Mohorovičić discontinuity (commonly referred to as the Moho), which marks the boundary between the Earth's crust and the upper mantle. Its depth varies: beneath oceanic crust it occurs at about 5–8 km, while beneath continental crust it lies at depths of 20–70 km.



*Exposure of Moho Discontinuity*



*Ultramafic Rocks of the Moho Zone*

One of the few places in the world where the transition from mantle rocks to crustal rocks can be observed at the surface – thanks to obduction – is the Moho exposure in Wadi Al Abyad. It extends for several metres. The mantle rocks are represented by peridotites (harzburgites and dunites), while the crustal rocks are composed of layered gabbros.

SOURCES:

Jarchow, C. M., & Thompson, G. A. (1989). The nature of the Mohorovičić discontinuity. *Annual Review of Earth and Planetary Sciences*, 17, 475–506. <https://doi.org/10.1146/annurev.ea.17.050189.002355>  
 Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). *Field Guide to the Geology of Northeastern Oman*. Borntraeger Science Publishers.

LOCATION: 24.1121944N, 56.5122500E

2

# Sheeted dykes

VISUAL APPEAL:

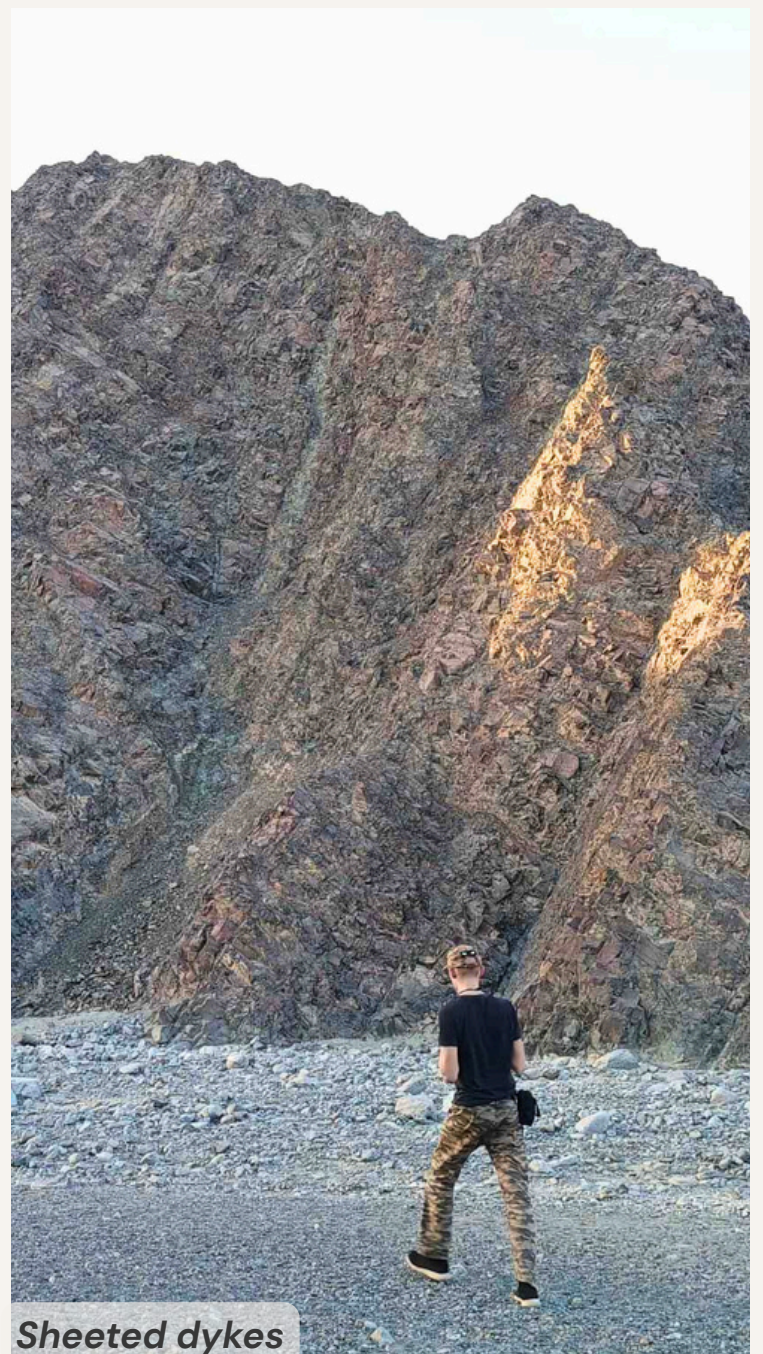


SCIENTIFIC VALUE:



Above the gabbros in the ophiolite profile, numerous vertical dykes occur. A dyke is a sheet-like magmatic intrusion that, during its formation, does not insert itself between existing rock layers but instead cuts across them. Such intrusions are described as discordant. In ophiolites, dykes form a characteristic complex of sheeted dolerite dykes.

One of the best exposures of these dykes is located in Wadi Al Hibi. There, nearly vertical intrusions ranging from 0.5 to 2 meters in thickness can be observed. Upon closer inspection, the crystals within the dykes appear larger in their central parts than along their margins. This is due to differences in magma cooling rates: in the central zone, cooling proceeded more slowly, whereas at the margins – where the magma was in contact with the older host rocks – it cooled more rapidly, giving the crystals less time to grow. Another distinctive feature is the cutting of older dykes by younger generations of dykes.



*Sheeted dykes*



*Sheeted dykes*

SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

Golonka, J., Słomka, T., Waśkowska, A. (2022). Geologia. Ziemia i procesy endogeniczne. Wydawnictwo AGH.

LOCATIONS: 24.2843803N, 56.3917319E | 24.2065081N, 56.5385483E

3

4

# Pillow lava

VISUAL APPEAL:



SCIENTIFIC VALUE:



Pillow lavas are among the most distinctive forms of extrusive igneous rocks. They form from basaltic lava flows that erupt on the ocean floor. Upon contact with cold water, the lava rapidly solidifies on the outer surface, creating rounded lobes. Due to the rapid crystallisation, large crystals do not form within them.

Since the eruption process can continue for an extended period, new pillow fronts develop on the surface, releasing fresh lava. Over time, the entire structure grows, and older lobes become flattened under the weight of the newer ones.



Pillow lava

Very well-preserved pillow lavas are exposed in Wadi Al Jizzi. This famous site is considered one of the most spectacular exposures of pillow lavas (known as the "Geotimes") of the Samail Ophiolite. The basalts are exposed over an area of 50 × 100 metres, and individual pillows reach diameters of 0.5 to 1 metre.



Pillow lava



Pillow lava

SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

Golonka, J., Słomka, T., Waśkowska, A. (2022). Geologia. Ziemia i procesy endogeniczne. Wydawnictwo AGH.

LOCATION: 22.9535633N, 58.2800842E

5



4WD REQUIRED

# Serpentinite with chromite

VISUAL APPEAL:



SCIENTIFIC VALUE:



Oman is one of the most important places in the world to observe exceptionally well-preserved outcrops of ultramafic rocks, including serpentinites and chromites.

The serpentinites in Oman formed as a result of hydrothermal alteration of oceanic mantle peridotites, mainly harzburgites and lherzolites. The serpentinization process occurred due to water infiltrating fractures in the upper mantle, leading to the formation of minerals such as antigorite, lizardite, and chrysotile. These rocks typically have a greenish color, a scaly texture, and display a characteristic mesh-like structure left by former olivine and pyroxene crystals.

Chromites occur as lenses and veins within the serpentinized peridotites, particularly in the harzburgite layers.



Serpentinite



Chromite

These deposits have economic significance — Oman is one of the key producers of chromite ores in the Middle East. Omani chromites are characterised by a high  $\text{Cr}_2\text{O}_3$  content and a relatively low  $\text{Fe}_2\text{O}_3$  content, making them an attractive industrial resource.

Outcrops of serpentinites and chromites are particularly well exposed in the Wadi Al Jizzi, Samail, Fizh areas, as well as in the Wadi Tayin massif. Thanks to their easy accessibility and excellent state of preservation, they serve as classic study sites for research on oceanic crust formation, subduction processes, and hydrothermal alterations in the upper mantle.

SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

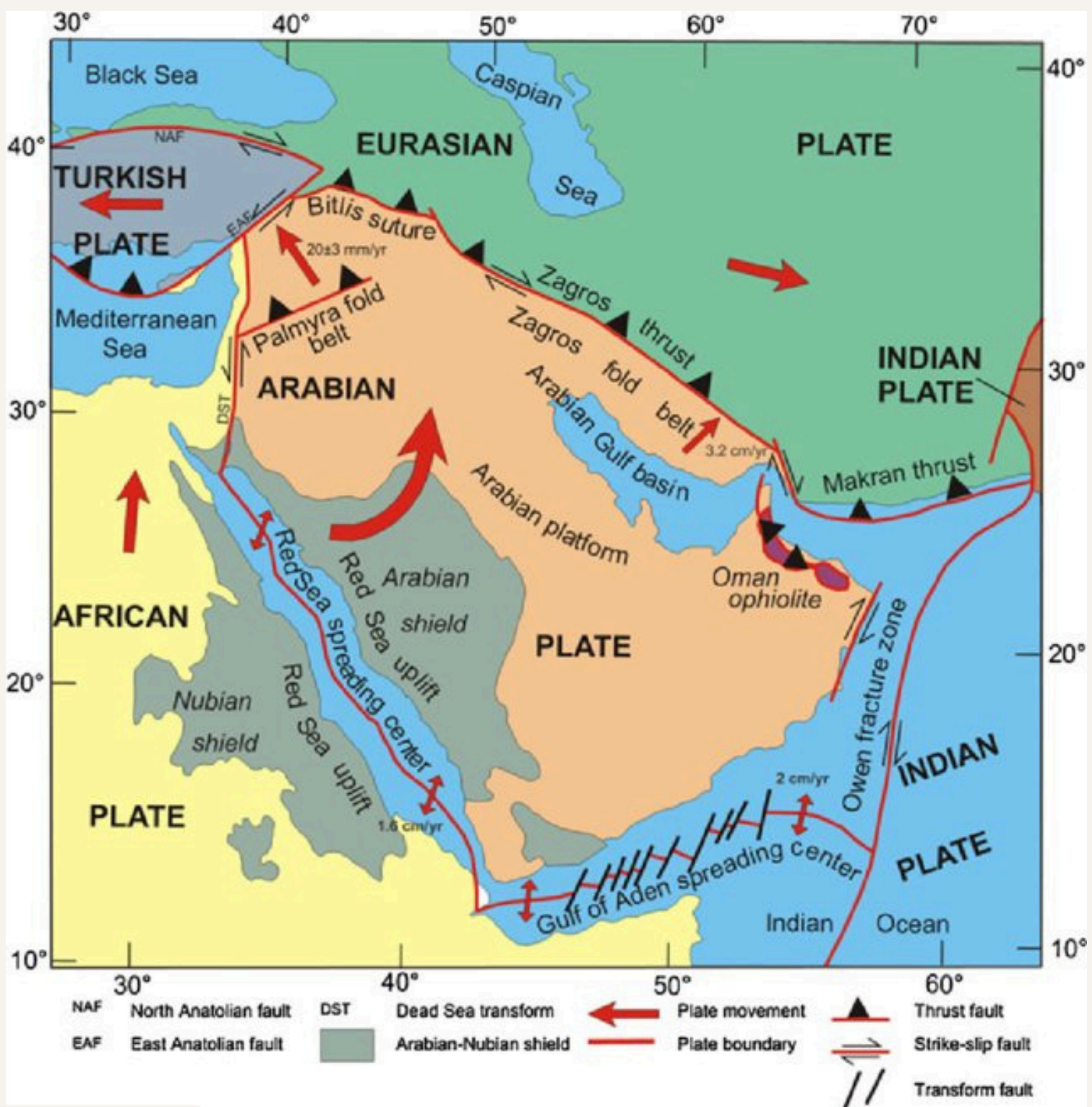
Sidduhiqui, F., Khan, M., Mansor, H., James, E., & Shah, Z. (2022). Exploration of chromite in Wadi Kalbu area, Nizwa, Sultanate of Oman. AIP Conference Proceedings, 2454(1). <https://doi.org/10.1063/5.0078344>

## CHAPTER 2

# Tectonic structures

# Tectonic in Oman

Oman is situated in the southeastern part of the Arabian Plate, bordering the African, Indian, and Eurasian plates. To the south, it is adjacent to the spreading zone of the Gulf of Aden, where new oceanic crust is formed. To the east, it is bounded by the Masirah transform fault – a strike-slip fault marking a tectonic plate boundary – and the Owen fault zone. The northeastern margin is defined by the complex convergent Zagros–Makran plate boundary, which separates the Arabian Plate from the Eurasian Plate. In the Makran subduction zone, the Arabian Plate is subducted beneath the Eurasian Plate. This zone can be subdivided into an eastern segment, characterized by frequent earthquakes, and a western segment, where seismic activity is much less pronounced. In contrast, the Zagros zone functions as a collision zone, where subduction does not occur.



Johnson (1998)

## SOURCES:

Poulos, H. G. (2018). A review of geological and geotechnical features of some Middle Eastern countries. *Innovative Infrastructure Solutions*, 3, Article 51. <https://doi.org/10.1007/s41062-018-0158-z>

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). *Field Guide to the Geology of Northeastern Oman*. Borntraeger Science Publishers.

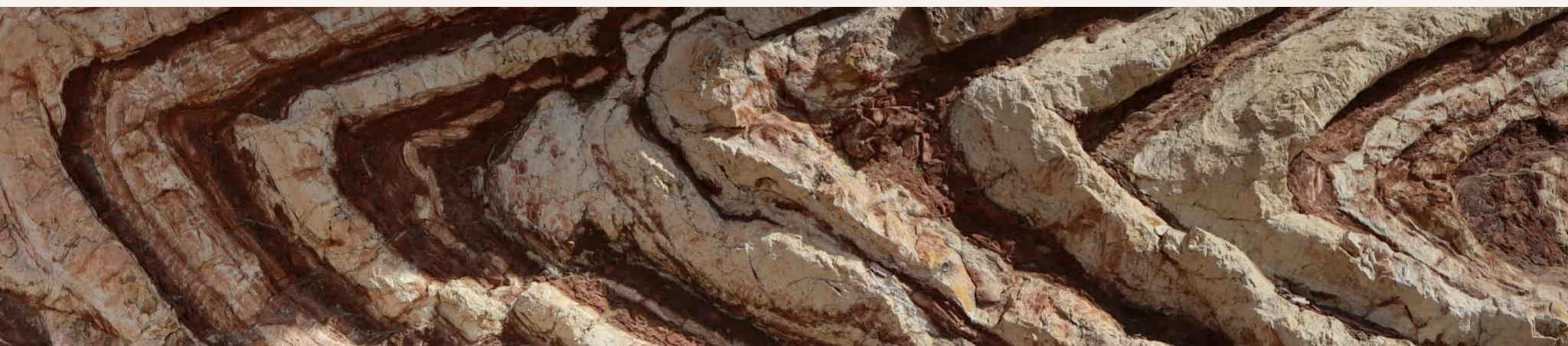
# Tectonic in Oman

The geological structure of Oman consists of seven main units, which can be grouped into three categories. The first group comprises autochthonous units, i.e., those that remain in the location where they were originally formed – on the Arabian Plate. These include the crystalline basement and its cover, which are mostly shallow-marine carbonates. The crystalline basement is composed primarily of metamorphic rocks (gneisses and mica schists) and magmatic intrusions cutting through them (dolerites/diabase, granodiorites, and granites). These rocks only exposed at the surface in eastern Oman.

The sedimentary cover (Autochthonous A) consists of sedimentary rocks from the late Proterozoic to the Carboniferous in intercontinental basins and on continental shelves. The Arabian Platform (Autochthonous B) includes the rocks of the Oman Mountains in the northern part of the country. Sedimentation began there in the late Permian and continued until the Late Cretaceous. Due to the subsidence of the Arabian Platform, carbonate sediments (limestones and dolomites) were deposited, forming an extensive carbonate platform. This process ended with uplift during the Cretaceous related with the obduction of the Samail Ophiolite.

The second group comprises allochthonous units, i.e., rocks that originally formed on the floor of the Neotethys Ocean, many kilometres from their present location. These include the Hawasina Nappe and the Samail Ophiolite. The Hawasina Nappe developed contemporaneously with the sediments of Autochthonous B, but in a different environment – a deep ocean basin. It consists of deep-sea deposits, including radiolarian cherts, pelagic shales, limestones, turbidite sandstones, and volcanic rocks. More on the ophiolite complex can be found in Chapter 1.

The third group comprises younger autochthonous units, formed after the emplacement and uplift of the nappes and ophiolites. This group includes a lithified sedimentary cover (mainly marls) deposited under marine conditions from the Late Cretaceous to the Neogene, as well as modern surficial sediments.



## SOURCES:

- GholamiZadeh, P., Wan, B., Meinhold, G., Esmaeili, R., & Ebrahimi, M. (2025). Provenance evolution from subduction to arc-continent collision: An example from the Zagros–Makran transition zone. *Geoscience Frontiers*, 16(4), 102079. <https://doi.org/10.1016/j.gsf.2025.102079>
- Searle, M. P., & Malpas, J. (1980). Structure and metamorphism of rocks beneath the Semail ophiolite of Oman and their significance in ophiolite obduction. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, 71(4), 247–262. <https://doi.org/10.1017/S0263593300013614>

LOCATION: 22.4584425N, 59.6991292E

6



4WD REQUIRED

# Chevron fold

VISUAL APPEAL:



SCIENTIFIC VALUE:



The outcrop located close to the village of Khawr Al Jaramah is referred to as the “Mother of All Outcrops”. It is composed of radiolarites – siliceous deep-sea rocks formed from the skeletal remains of microfossils named radiolarians and shale. Radiolarites occur as a hard, low-porosity rock consisting chemically of microcrystalline quartz.

The outcrop is 5–7 metres high and 25 metres long, and its face displays folded and faulted layers of alternating white and red strata of the Cretaceous Wahrah Formation, each 5–10 cm thick. The red layers are radiolarites, while the white ones are porcelanite – a siliceous rock resembling unglazed porcelain, less hard and less compact than radiolarite.



*Chevron fold and faults*

Radiolarites formed as a result of the deposition of radiolarian tests in deep-sea sedimentary basins. This type of rock indicates that sedimentation during the Cretaceous took place at a depth of about 3,500 meters, below the calcite compensation depth (CCD), where calcite dissolves and carbonate rocks cannot form.

The appeal of this outcrop lies in its numerous tectonic deformations: folds and faults. On the left side, a recumbent chevron fold is visible, characterised by fold limbs arranged in a V-shape. These structures formed during the displacement of the Batain Nappe onto the eastern margin of the Arabian Plate.



*Chevron fold*

SOURCES:

<https://www.mindat.org/min-994.html> (access: 15.09.2025).

<https://www.mindat.org/min-9727.html> (access: 15.09.2025).

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

Golonka, J., Słomka, T., Waśkowska, A. (2022). Geologia. Ziemia i procesy endogeniczne. Wydawnictwo AGH.

LOCATION: 23.5017500N, 58.6258889E

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# Megafold

VISUAL APPEAL:



SCIENTIFIC VALUE:



The megasheath fold is located in the Wadi al Mayh region of northeastern Oman. It is exposed over a distance of more than 15 metres and trends to the northeast. It formed as a result of tectonic processes – specifically, the subduction of the margin of the Arabian Platform – occurring at the end of the Cretaceous. This structure is among the largest and best-exposed examples of its kind worldwide.



*Sheath fold*

Sheath folds are asymmetric, continuous tectonic structures that develop through intense deformation and characteristic rotation of rock material. The rocks involved in the folding are carbonate deposits formed in a marine environment during the Permian (around 260 million years ago), and possibly also slightly later, in the Triassic. These rocks were subsequently subducted and exhumed during the Samail Ophiolite emplacement, which led to their deformation. The entire structure formed during intense ductile deformation at approximately 76–70 million years ago.



*Sheath fold*

SOURCES:

Reber, J., Dabrowski, M., & Schmid, D. W. (2012). Sheath fold formation around slip surfaces. *Terra Nova*, 24(5), 420–427. <https://doi.org/10.1111/j.1365-3121.2012.01081.x>

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). *Field Guide to the Geology of Northeastern Oman*. Borntraeger Science Publishers.

Searle, M., & Alsop, G. (2007). Eye-to-eye with a mega-sheath fold: A case study from Wadi Mayh, northern Oman Mountains. *Geology*, 35(6), 523–526. <https://doi.org/10.1130/G23884A.1>

## CHAPTER 3

# Sedimentary rocks and wadis



VIEW POINT LOCATION: 23.2124458N, 57.2041142E

8

## The role of water in shaping the landscape

Water is one of the most important factors shaping the Earth's surface. Its action covers a wide range of processes – from rock erosion, through clastic material transport, to its accumulation. These processes lead to constant changes in the terrain. Depending on its state of aggregation, water affects the Earth's surface in different ways.

In areas of the dry tropics, such as Oman, fluvial and karst processes play a dominant role. Although there are no permanent rivers with year-round flow in Oman, during short but intense rainfall, seasonal rivers form, filling the dry valleys – wadis.

Rapid surface runoff during storms and monsoon rains leads to severe erosion, transport of rock debris, and its deposition in lower parts of valleys. This creates characteristic alluvial fans and river deposits, which are often the only source of fertile soil in this country. These phenomena, although crucial for shaping the landscape, can also be destructive – intense flooding in wadis leads to damage to road infrastructure and bridges, and also poses a real threat to the population.

Some rainwater soaks into the ground, leading to infiltration and chemical weathering. In places where the ground is composed of carbonate rocks, water containing carbon dioxide causes a chemical reaction, leading to the dissolution of minerals and the formation of karst such as caves and sinkholes. In Oman, these phenomena are particularly evident in the Al-Hajar Mountains, where there are extensive limestone massifs are outcropping.

Although water rarely appears in Oman on the surface, it plays an important role in shaping the landscape. Its sporadic but intense occurrence leads to both rapid changes in the terrain and slow geochemical processes that have shaped the Omani landscape over thousands of years. Furthermore, the massive appearance of karst features, omnipresent in Oman, testifies that the climate in the recent past (i.e., during the last interglacial) was much more pluvial than today.



### SOURCES:

Golonka, J., Słomka, T., & Waśkowska, A. (2023). *Geologia. Ziemia i procesy egzogeniczne*. Wydawnictwo AGH.  
Klimaszewski, M. (1978). *Geomorfologia*. Wydawnictwo Naukowe PWN.

# What is a wadi?

Wadi is a term used in the countries of the Arabian Peninsula to describe a river valley, through which water flows only periodically. Unlike ordinary riverbeds, wadis are dry for most of the year, and only in well-shaded, cooler places does water remain for longer periods of time.

During such episodic downpours, streams with high erosive power can flow rapidly through wadis, transporting rock and gravel material from higher areas towards lower parts of the valley. These processes result in characteristic fluvial forms such as river terraces, alluvial fans, and erosive valley walls.

In Oman, wadis are one of the most characteristic features of the landscape – they cut through the desert plains and the Al-Hajar Mountains, often forming scenic canyons with steep limestone walls. An example of such a valley is Wadi Ghul, often referred to as the “Grand Canyon of Arabia” with a depth exceeding 1,000 metres.



*River deposits (alluvium) in Wadi Ghul*

## SOURCES:

<https://www.worldatlas.com/articles/fluvial-landforms-what-is-wadi.html> (access: 12.09.2025).

VIEW POINT LOCATION: 23.2124458N, 57.2041142E

8

# What is Wadi Ghul Canyon made of?

VISUAL APPEAL:

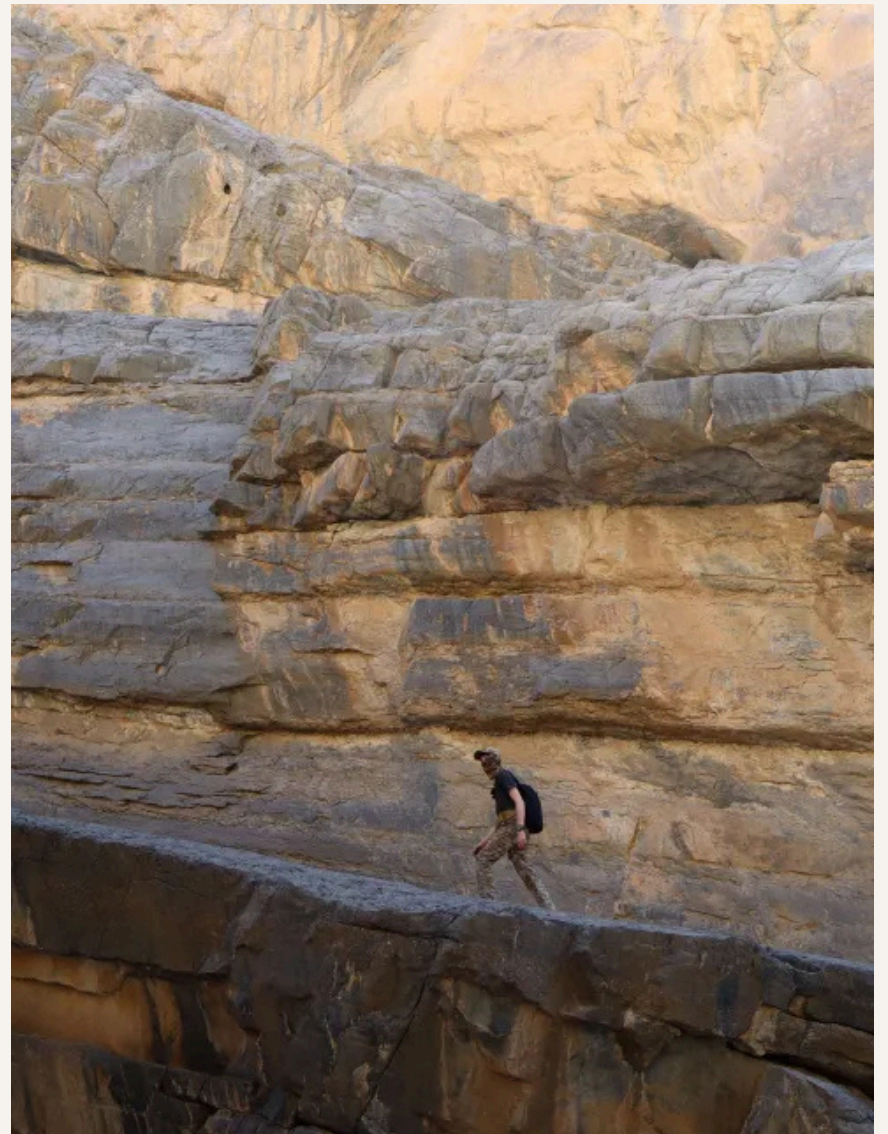


SCIENTIFIC VALUE:



From a geological point of view, Wadi Ghul is mainly composed of Jurassic and Cretaceous limestone and dolostone. These rocks were deposited at the Arabian Shelf.

From the Early Jurassic to the Late Cretaceous, intensive carbonate sedimentation took place in a shallow, warm sea, leading to the accumulation of approximately 3,000 m of carbonate sediments. Later, in the Late Cretaceous, as a result of the subduction of the Arabian Plate beneath the Eurasian Plate, complex tectonic processes took place: uplift, folding, and thrusting of the ophiolite complex onto the carbonate platform. Eventually, the rocks were uplifted again during the Eocene to Oligocene when the Jabal Akhdar uplifted.



*Thick layers of sedimentary rocks in Wadi Ghul*



*Bottom of Wadi Ghul*

The walls of the canyon reach over 1,000 metres in height in places, and the difference in height between its edge (approx. 1900–2000 m above sea level) and the bottom (approx. 900 m above sea level) exceeds 1000 metres, making it the deepest canyon on the Arabian Peninsula. Lithological variability is also visible in the cross-section of the walls. Massive, light grey limestones form vertical cliffs, while more malleable dolostones and marls weather faster. This creates rock shelves visible in the walls.

SOURCES:

<https://geoexpo.com/the-best-geological-site-in-the-middle-east> (access: 12.09.2025).

VIEW POINT LOCATION: 23.1527292N, 57.2047431E

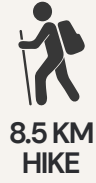
9

# What the rocks hide in Wadi Guhl?

VISUAL APPEAL:



SCIENTIFIC VALUE:

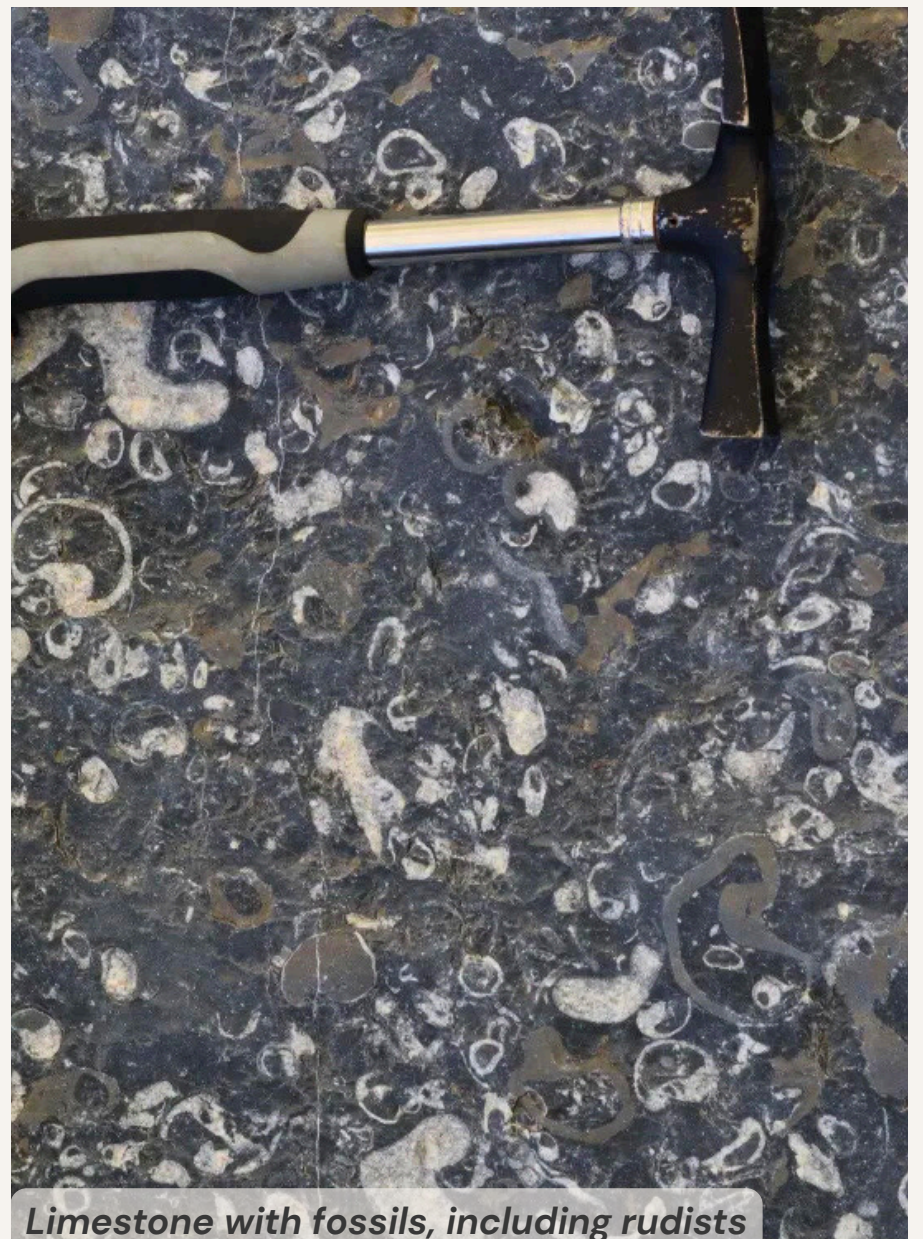
8.5 KM  
HIKE

4WD REQUIRED

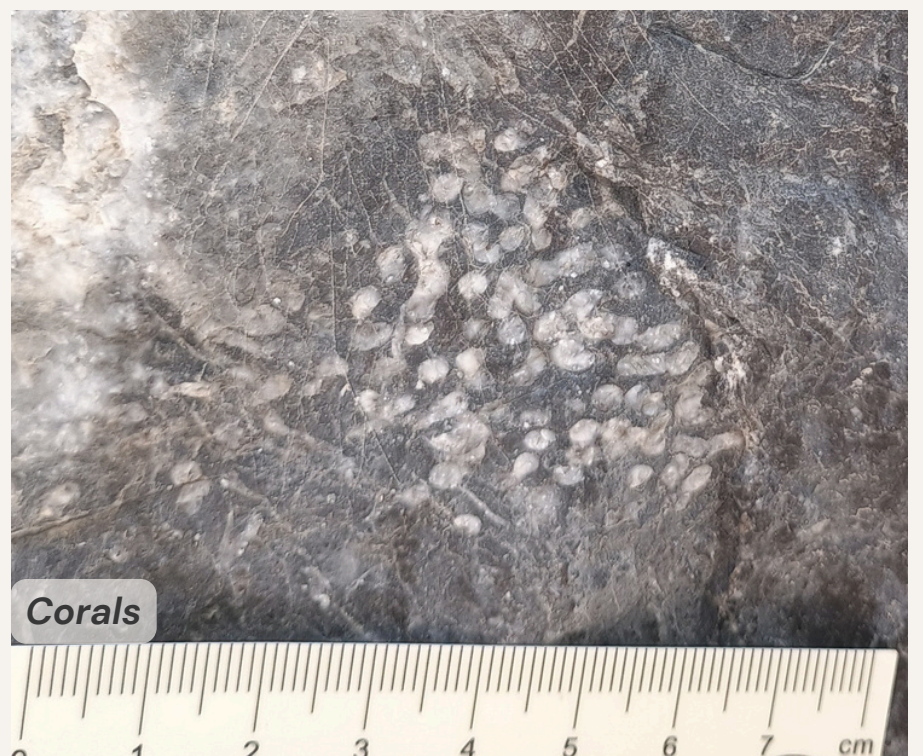
When walking along the bottom of Wadi Ghul, you should definitely take a close look at the local rocks. It is a unique opportunity to see a great number of fossils, mainly animals belonging to the group known as invertebrates.

The most abundant here are bivalves. They belong to the molluscs and are characterised by shells made of two valves, inside which the soft body is enclosed. The two valves are usually the same size and shape, forming mirror images of each other. After the organism's death, the shell typically separates into two individual valves, which we find in a fossilised state. In Wadi Ghul you can also find very unusual bivalves called rudists, which can have a size of 1 meter. Their structure is more reminiscent of corals — one valve is cone-shaped and the other forms a lid that closes it. In the Cretaceous period, they formed characteristic rudist reefs.

Another type of fossil that can be seen in Wadi Ghul are corals. These are animals classified as cnidarians. They occur as solitary individuals or form colonies. Fossils of corals that built calcareous skeletons are common in rocks formed in shallow zones of warm seas. Today, corals are known as the main builders of reefs, and in the geological past various groups of corals also played an important role as reef-forming organisms.



*Limestone with fossils, including rudists*

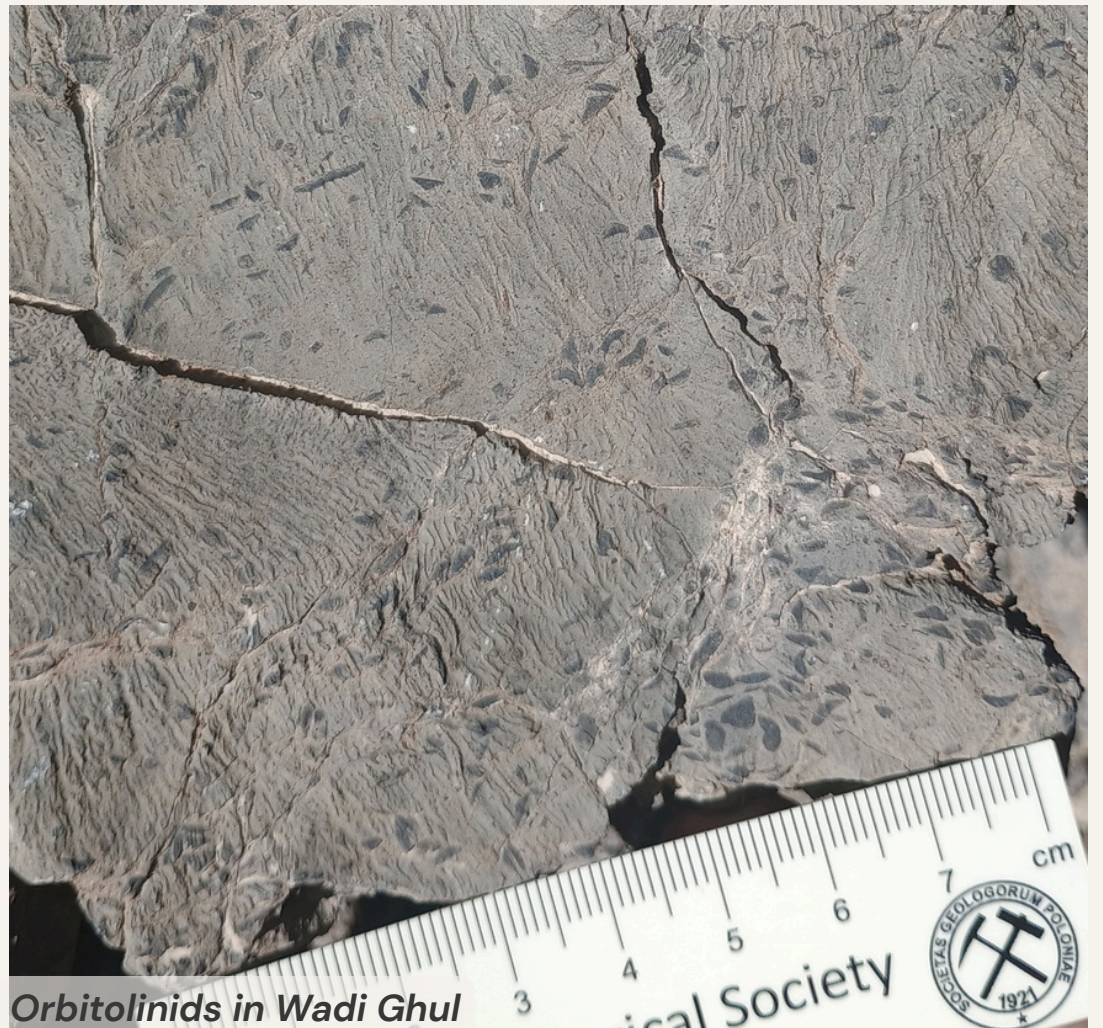


*Corals*

SOURCES:

Lehmann, U., & Hillmer, G. (1991). *Bezkręgowce kopalne*. Wydawnictwa Geologiczne.  
Radwańska, U. (2003). *Podstawy paleontologii*. Wydawnictwo Uniwersytetu Warszawskiego.

Different type of fossil can be spotted by the skilled eye in the upper part of the canyon, while walking through the Balcony Walk (see next page). Small, dark orbitolinids stand out clearly against the grayish-yellow marly rocks. They belong to the foraminifera, classified as microfossils, but compared to other foraminifera, they reach such large sizes that they are visible to the naked eye. They are characteristic of the mid-Cretaceous. They lived in warm and shallow seas, often coexisting with rudists.



*Orbitolinids in Wadi Ghul*



*Oncoids in Wadi Ghul*

Fossils are not the only components of carbonate rocks that can be seen in Wadi Guhl. Beautiful oncoids, a type of coated grains, are also easy to spot there. They have sub-rounded shapes and consist of concentric laminae covering a nucleus, which may be, for example, fragments of fossils. They are usually several millimetres to several centimetres in size. The carbonate layers covering the nucleus are formed with the participation of organisms, such as algae.

The oncoids visible in the photo from Wadi Guhl are up to 2 cm in size and quite irregular. Their nuclei often consist of small fragments of bivalve shells.

Tip: Oncoids, as well as fossils, are often more visible after pouring water on the rock surface.

Although some specimens you find may be very tempting, before attempting to take them with you, make sure that they are not protected. If you are unsure, it is better to leave them where they are and take a photo than to risk breaking the law.

#### SOURCES:

Flügel, E., & Munnecke, A. (2010). *Microfacies of carbonate rocks: analysis, interpretation and application*. Springer.  
 Simmons, M. D., Whittaker, J. E., Jones, R. W., & Hart, M. B. (2000). Orbitolinids from Cretaceous sediments of the Middle East—a revision of the FRS Henson and Associates Collection. *Grzybowski Foundation Special Publication*, 7, 411–437.

CAR PARK: 23.1937197N, 57.2012414E

TRAIL BEGINNING: 23.1934472N, 57.2020769E

10

# Balcony Walk Trail

VISUAL APPEAL:



SCIENTIFIC VALUE:



The “Balcony Walk” is a trail that runs along the Wadi Ghul canyon. Its length is approximately 7.5 km, and completing the entire route takes about 3–4 hours. The starting point of the trail, as well as the entire route, is situated at around 1,900 metres above sea level. The trail itself is well marked – red and yellow signs painted on the rocks are clearly visible, making it easy to know where to go.

Along the way, hikers can enjoy breathtaking views, examine the limestone and marly limestone formations that make up the canyon, and appreciate the scale of the deepest canyon on the Arabian Peninsula. At the end of the trail, the ruins of the old village of As-Sab can be seen, including abandoned houses and agricultural terraces. At the very end, a natural reservoir is present. This small lake is located beneath a waterfall and served as a reservoir for the village. Today, besides tourists, one can also encounter goats skillfully navigating the steep rocks.



*Balcony Walk trail*



*Balcony Walk trail*

The trail is not particularly demanding – most of it is wide and not very exposed. It is recommended to hike in the early morning or late afternoon, when the sun is not as strong.

To reach the starting point of the trail, it is necessary to drive there by car. Most of the road is paved, especially along the numerous switchbacks, and where the road is unpaved, it is in good condition, a 4x4 vehicle is not required but preferred.

SOURCES:

<https://geoexpo.com/the-best-geological-site-in-the-middle-east> (access: 12.09.2025).

LOCATION: 23.0358356N, 59.0719333E

13

# Wadi Shab

VISUAL APPEAL:



SCIENTIFIC VALUE:



Wadi Shab, located near the town of Tiwi on Oman's eastern coast, is one of the most beautiful wadis in the country. The picturesque canyon cuts through the rocks of the Al-Hajar Mountains, forming a landscape of remarkable beauty with turquoise pools, green palm groves, and a waterfall hidden inside a cave. Access to the interior of the valley begins with a short boat crossing, followed by a hike among steep cliffs and natural basins filled with crystal-clear water. The place is popular among nature lovers, hikers, and those who enjoy swimming in natural pools.



*Wadi Shab*



*Limestone walls with karst cavities*

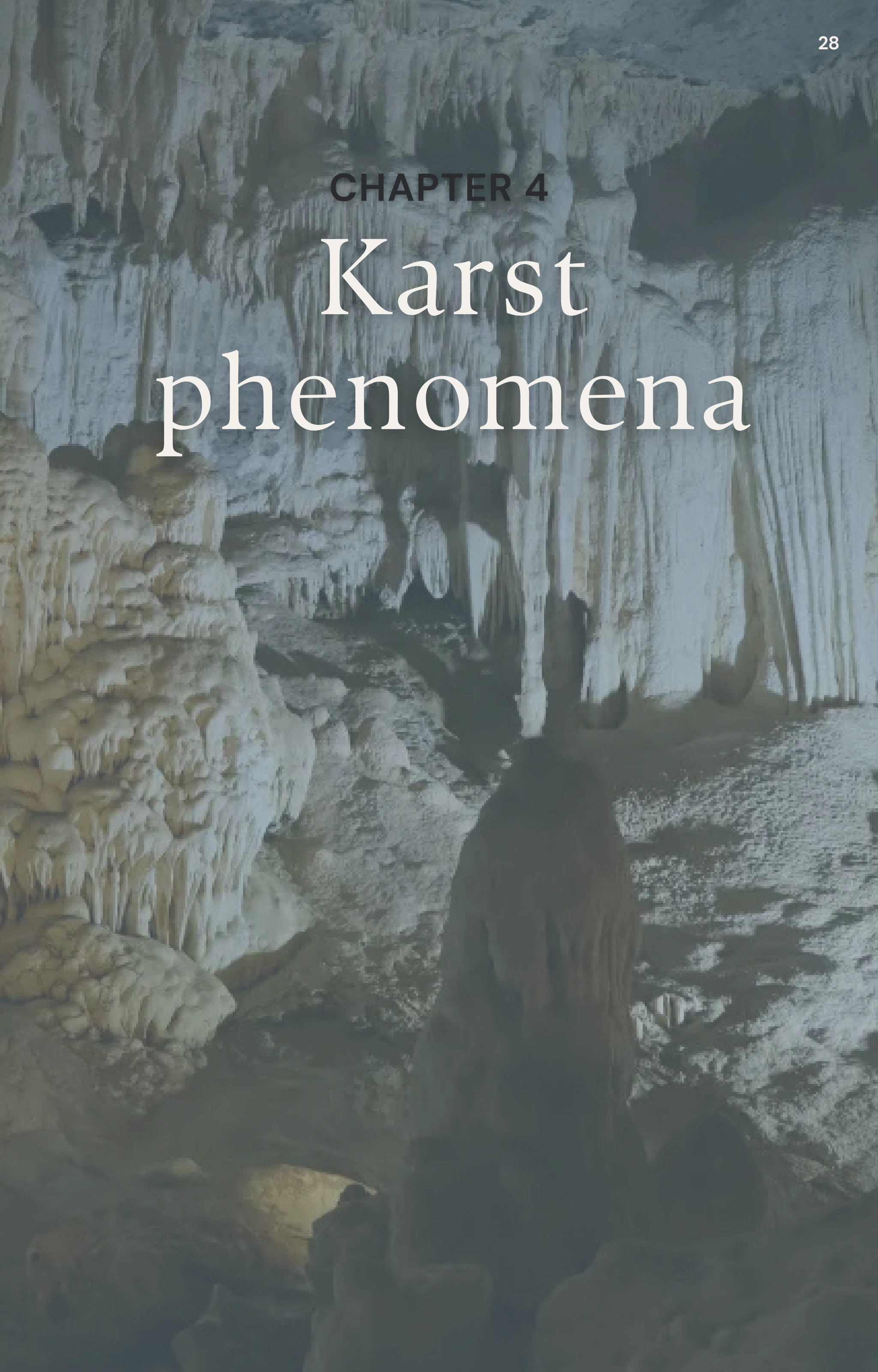
From a geological point of view, Wadi Shab cuts through Eocene limestones and marls belonging to the Sur and Hadhramaut formations. These rocks formed in a shallow, warm sea that existed here after the closure of the Neo-Tethys Ocean and the uplift of the Al-Hajar Mountains. As a result of fluvial erosion and tectonic processes, deep valleys and cave systems developed, some of which still drain water from karst springs today.

SOURCES:

Glennie, K.W. (1995). *The Geology of the Oman Mountains: An Outline of Their Origin*. Elsevier.  
 Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). *Field Guide to the Geology of Northeastern Oman*. Borntraeger Science Publishers.

## CHAPTER 4

# Karst phenomena



# Karst in Oman

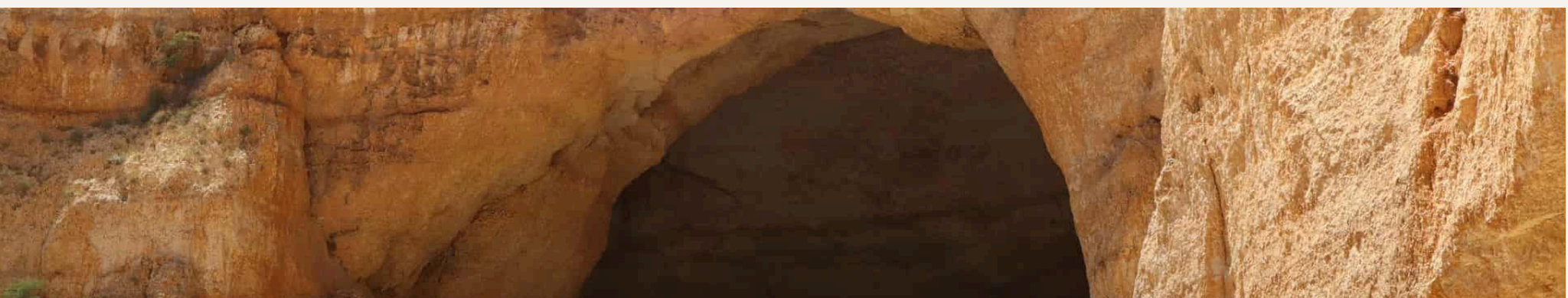
Let us go back more than 140 million years, to a period known as the Early Cretaceous, when Oman was situated much closer to the equator than it is today. At that time, the landscape of Oman was dominated by extensive carbonate platforms. Over time, these were gradually submerged by the waters of a developing foredeep basin. In deep-marine, tropical conditions, rapid sediment deposition and intensive biogenic production took place. Toward the end of the Cretaceous, sea level gradually fell, creating a shallow-marine shelf environment.

These conditions favoured the development of reef and pelagic biocenoses. From the accumulated remains of marine organisms, carbonate rocks were formed, including dolomites and limestones susceptible to dissolution by calcium-carbonate-rich water.

In the Neogene, already in a terrestrial environment, progressive erosion exposed rocks prone to karstification. The tropical continental climate, characterised by high humidity, promoted the intensification of chemical weathering. Fractures and drainage systems developed, giving rise to later karst processes.

The modern development of karst landforms, due to the dominance of relatively dry desert and semi-desert areas, depends on seasonal surface watercourses and monsoon rains. Most drainage, however, occurs underground. Water from the surface infiltrates through a network of microfractures and fissures deep into the rocks, where it circulates and gradually dissolves them. Existing voids may sometimes enlarge to dimensions that allow human entry. At that point, we can speak of caves.

The main karst areas known from Oman occur near the Al-Hajar Mountains, on the Salma Plateau (sometimes also referred to as the Tiwi Platform), and northeast of the town of Salalah in Dhofar. So far, nearly 200 cave sites have been inventoried within Oman. It is believed that this number may increase significantly in the coming years. After all, who knows how many caves still remain hidden high in inaccessible mountains or buried beneath desert sands, waiting for their discoverers...



## SOURCES:

- Al-Kindi, M. H., & Hird, R. (2020). A review of natural geological hazards in Oman. *Environmental Earth Sciences*, 79, 381. <https://doi.org/10.1007/s12665-020-09124-x>
- Al-Rawahi, Z., & Jones, T. D. (2019). Calcareous nannofossil assemblages of the Late Cretaceous Fiqa Formation, north Oman. *Journal of Micropalaeontology*, 38(1), 25–54. <https://doi.org/10.5194/jm-38-25-2019>
- Golonka, J., Słomka, T., & Waśkowska, A. (2023). *Geologia. Ziemia i procesy egzogeniczne*. Wydawnictwo AGH.
- Al-Kindi, M. H., et al. (2022). *A guide to the caves of Oman (Arabic edition): The remarkable subterranean world of the Sultanate of Oman*. Nomad Publishing.

LOCATION: 23.0812197N, 57.3506411E

11

# Al Hoota Cave

VISUAL APPEAL:

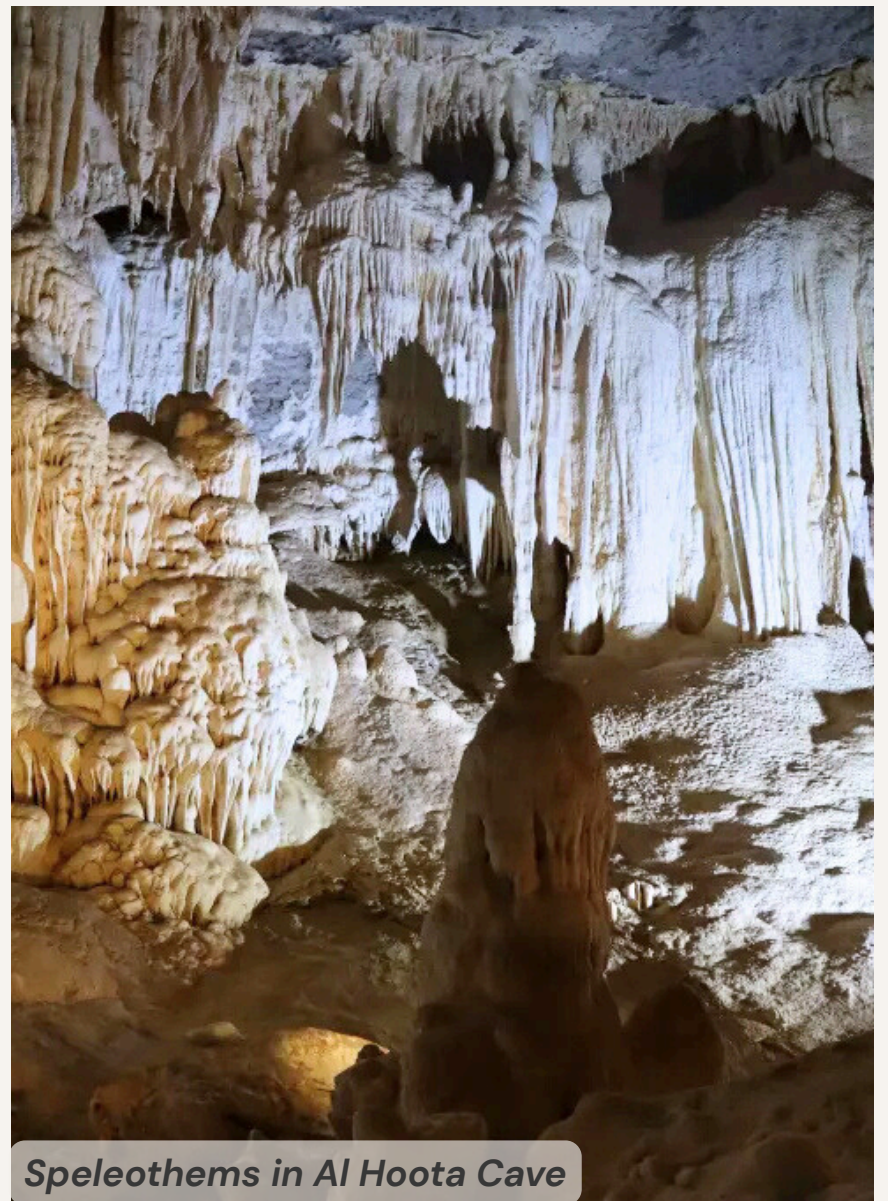


SCIENTIFIC VALUE:

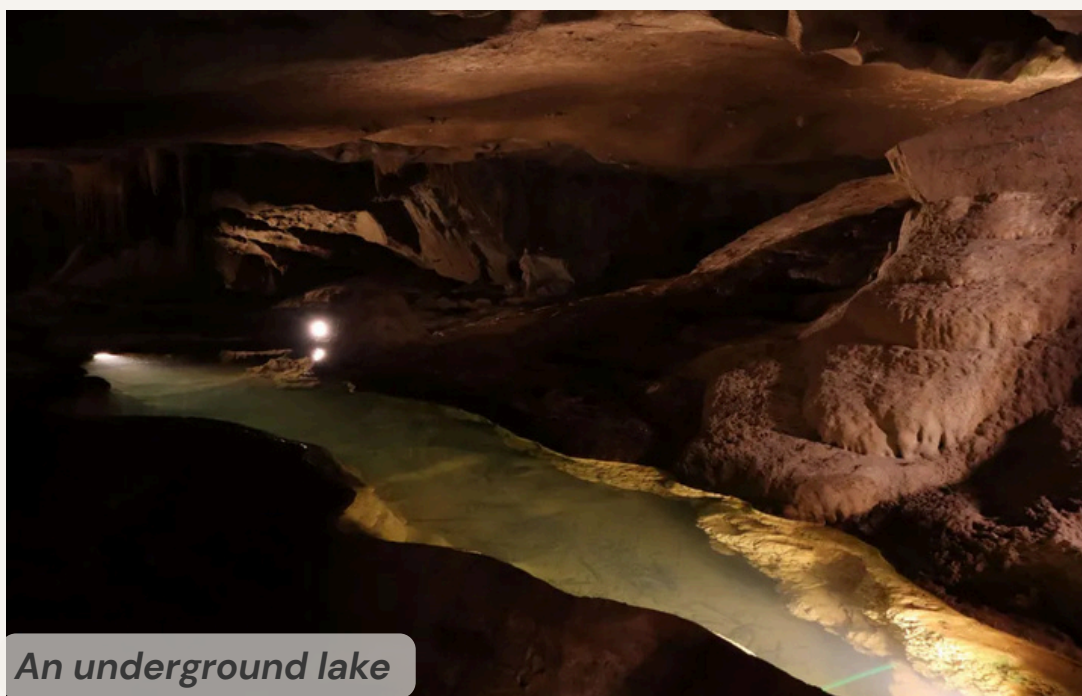


The corridors of Al Hoota Cave, stretching over 5 km and developed within Upper Cretaceous limestones, make it the longest single cave discovered not only in Oman but across the entire Arabian Peninsula. The underground ecosystem includes four lakes, with the largest reaching a depth of 15 metres. Of particular note is the well-developed and still active speleothem formation, where visitors can observe several-metre-high stalagmites, stalactites, draperies, and columnar formations with imaginative shapes.

The cave is also home to unique creatures. The underground waters of Al Hoota Cave are particularly favoured by the fish species *Garra barreimiae*. These slender, small fish — growing up to just 8 cm in length — were until recently found only in the desert wadis of the United Arab Emirates, Oman, and Bahrain, where the



Speleothems in Al Hoota Cave



An underground lake

species is endemic. This changed in 1980, when a population was discovered in the lakes of Al Hoota Cave. The cave-dwelling fish have adapted to life in the extremely challenging subterranean environment. They have evolved into a blind, pigmentless form, with scales greatly reduced compared to their surface-dwelling relatives.

SOURCES:

<https://www.atlasobscura.com/places/al-hoota-cave> (access: 25.09.2025).

Bruthans, J., et al. (2018). Origin of honeycombs: Testing the hydraulic and case hardening hypotheses. *Geomorphology*, 303, 68–73.

<https://pl.wikipedia.org/wiki/Tafone> (access: 25.09.2025).

Each year, the cave attracts over 40,000 thrill-seeking tourists. For their benefit, a 500-metre underground tourist route in the form of a loop, accessible with a guide, has been opened. In line with sustainable tourism principles, the route is equipped with an advanced lighting system that allows lights to be turned on during visits and switched off when not in use. This prevents unnecessary disturbance to the cave's wildlife. Additionally, it helps avoid the growth of so-called "lamp flora", which can disrupt the ecosystem and cause unwanted changes to the cave's microclimate. Especially that this microclimate is unique. The underground isolation, combined with constant air circulation, ensures a stable temperature of 20°C throughout the year.



*Tourist trail in Al Hoota Cave*



*Tourist trail in Al Hoota Cave*

The water level of the underground lakes, however, depends on seasonal changes, as they are primarily fed by groundwater and rainfall. After heavy rains, especially during the monsoon season, the water level in the underground lakes can rise rapidly. This can partially flood the corridors and lower-lying infrastructure, leading to temporary closures of the cave for visitors. Although this phenomenon is hazardous, it is essential for maintaining the proper balance of this unique underground ecosystem.

#### SOURCES:

- <https://web.archive.org/web/20151208140221/http://www.arkive.org/omani-blind-cave-fish/garra-barreimiae/> (access: 25.09.2025)  
<https://www.muscatdaily.com/2025/01/02/al-hoota-cave-witnesses-visitor-surge-with-new-attractions/> (access: 25.09.2025)  
<https://www.alhootacave.om/the-cave/> (access: 25.09.2025)  
 Różowicz, A. (2006). Wpływ oświetlenia na zmiany szaty naciekowej w jaskiniach. W POOMT 2006: Proceedings of the II Conference (4–6 October 2006, Krasieczyn, Poland).  
<https://omanwanderlust.com/al-hoota-cave-omans-show-cave/> (access: 25.09.2025)  
<https://www.showcaves.com/english/om/showcaves/AlHoota.html> (access: 25.09.2025)

TRAIL BEGINNING: 22.8861319N, 59.1323728E  
 CAVE LOCATION: 22.8638678N, 59.1367803E

12



8.2 KM HIKE 4WD REQUIRED

# Tahery Cave

VISUAL APPEAL:



SCIENTIFIC VALUE:



*Entrance to the Tahery Cave*

The Tahery Cave is part of a larger cave system known as the 7th Hole Cave, and it forms its lowest section. During floods and heavy rainfall, the entrance to the Tahery Cave serves as a drainage outlet for the water. As the swollen water flows down the steep mountain slopes and then passes through the upper sections of the cave system, it carries with it rock material torn away along the way. Evidence of this includes numerous boulders — some several metres in size — embedded in the cave floor, as well as sandy-gravelly sediments, periodically deposited by the water. The limestone rocks underwent repeated erosion, gradually expanding and shaping both the cave corridors and the entrance opening into their current dimensions. This process is still ongoing, and the violent floods pose a deadly threat. It is worth keeping this in mind when planning a caving trip in the area.

The Salmah Plateau is well known to every lover of extreme adventures. It is home to several spectacular caves, such as the Tahery (Al Tahiri) Cave. To reach it, one must follow a two-hour trail that runs along a canyon. The cave itself is hard to miss. Its impressive size is evidenced by the trees growing inside, barely visible against the backdrop of an entrance opening more than 20 metres high. And how did it form? It was shaped by the flash floods that frequently occur in this region.



*Stalagmites in the Tahery Cave*

SOURCES:

<https://omantripper.com/tahery-cave/> (access: 25.09.2025)  
[https://en.wikipedia.org/wiki/Majlis\\_al\\_Jinn](https://en.wikipedia.org/wiki/Majlis_al_Jinn) (access: 25.09.2025)

The Tahery Cave is open for self-guided exploration. A marked trail leads to the vicinity of the cave's entrance. In the deeper sections, your own source of light is essential. Most of the cave corridors are horizontally developed, spacious, and relatively easy to move through. However, one must watch out for numerous deep fissures that are easy to fall into. The more technically demanding sections are equipped with fixed ropes or suspended ladders. Reflective markers help with orientation. The cave is recommended for people with prior experience in non-tourist caves. Venturing into the deeper parts requires advanced speleological and climbing skills, as well as specialist equipment.



Tahery Cave

Less than seven kilometres from the Tahery Cave, the Majlis Al Jinn Cave is situated. It was here that a sensational discovery was made in 1983. Descending 118 metres on a rope into a rocky fissure, W. Don Davison reached the bottom of a giant underground chamber with a volume of 4 million cubic metres. At that time, this ranked it as the second-largest cave chamber in the world.

The cave immediately gained fame in the speleological community. From then on, it was called Majlis al Jinn, which in Omani Arabic literally means “the place where the jinn meet”.

#### SOURCES:

<https://omantripper.com/tahery-cave/> (access: 25.09.2025)  
[https://en.wikipedia.org/wiki/Majlis\\_al\\_Jinn](https://en.wikipedia.org/wiki/Majlis_al_Jinn) (access: 25.09.2025)

LOCATION: 23.0358356N, 59.0719333E

13

# Bimmah Sinkhole

VISUAL APPEAL:



SCIENTIFIC VALUE:



Legend has it that, in ancient times, a falling star struck with unimaginable force the plain separating the ocean from the sheer peaks of the Al Hajar Mountains. This, it is said, is how Oman's "green eye" was formed. The truth is quite different, yet no less fascinating. The Bimmah Sinkhole is a textbook example of a karst collapse. It was created through the dissolution of Eocene limestone. The high porosity of these rocks favours karst processes. As a result, the surface layer of rock — which once formed the roof of a cave — collapsed.



*Bimmah Sinkhole*



*Bimmah Sinkhole*

This created a sinkhole 70 metres wide and 20 metres deep, which quickly filled with highly transparent water. Interestingly, the water tastes slightly salty, due to fresh rainwater mixing with salty seawater. This is due to seawater seeping through a network of underground karst channels connecting the sinkhole to the Sea of Oman.

SOURCES:

<https://www.ghmhotels.com/en/blog-ghmjournays/oman/the-tale-of-the-falling-star-of-oman/> (access: 25.09.2025)  
Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

## CHAPTER 5

# Wahiba Sands Desert

WAHIBA SANDS DESERT: 22.3854689N, 58.7051306E

14



4WD REQUIRED

# Geological structure

The Wahiba Sands Desert, in eastern Oman, is distinguished by warm sand colours ranging from yellow and ochre to orange and red. These hues can change depending on the angle of sunlight. The colours result from thin coatings of iron oxides, mainly hematite and limonite, covering the quartz grains.

The substrate of the desert consists of older limestones, dolostones, sandstones, and ophiolite, which are completely overlain by a thick layer of loose sand, reaching up to two hundred metres in thickness. These deposits originated from material transported by rivers and wadi systems from the Al-Hajar Mountains, and over thousands of years were reworked and shaped by wind.

In some places, the thickness of the sand layer reaches up to 200 metres.



Ripplemarks



Colors of the Wahiba Sands Desert

Beneath the loose sand cover, within the rocky basement of the desert, lie aquifers — largely relict in nature — formed during periods when the region's climate was more pluvial than it is today.

## SOURCES:

Pease, P. P. (1999). Mineralogical characterization and transport pathways of dune sand using Landsat TM data, Wahiba Sand Sea, Sultanate of Oman. *Geomorphology*, 29(3–4), 235–249. [https://doi.org/10.1016/S0169-555X\(99\)00029-X](https://doi.org/10.1016/S0169-555X(99)00029-X)  
 Gheith, A., et al. (2021). Petrography and heavy minerals analysis for recognition of the depositional history of the Wahiba Sand Sea, Sultanate of Oman. *Arabian Journal of Geosciences*, 14, 1444. <https://doi.org/10.1007/s12517-021-07790-0>

WAHIBA SANDS DESERT: 22.3854689N, 58.7051306E

14



4WD REQUIRED

# Aeolian landforms

VISUAL APPEAL:



SCIENTIFIC VALUE:



The Wahiba Sands Desert impresses with its diversity of aeolian forms that shape its characteristic landscape. The most striking are the extensive, elongated dunes forming long, parallel sand ridges developed in accordance with the prevailing N-S wind direction. These dunes display clearly defined windward and leeward slopes, which emphasise the direction of sand transport and testify to the intense aeolian activity. In many places, they form extensive systems of interconnected ridges that can stretch for tens of kilometres, giving the desert its undulating, rhythmic appearance.

Locally, smaller features also occur, formed as a result of variable sand transport conditions, such as accumulations at the bases of dunes or minor deposits appearing where airflow becomes disrupted, for example by the presence of plants (nebkha). These structures reflect local changes in wind strength and the amount of available aeolian material, revealing the complexity of the processes that shape the desert surface.

The diversity of these forms is not only the result of contemporary wind dynamics but also a record of climatic changes that in the past influenced dune activity and stabilization. For this reason, the Wahiba Sands represent a remarkable example of an area in which aeolian sedimentary processes are clearly expressed in the landscape.

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*Linear dunes*



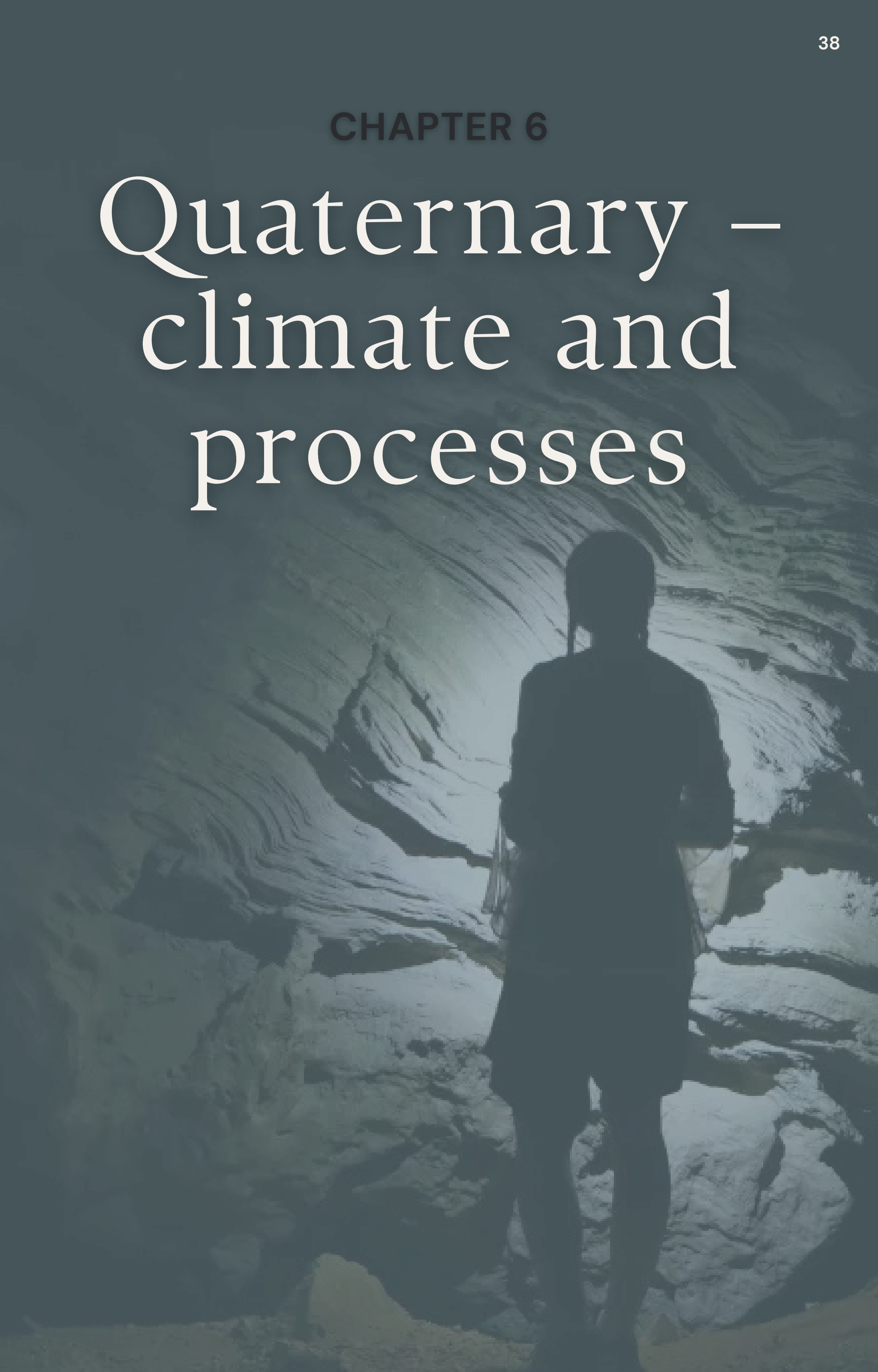
*Nebkha*


SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

## CHAPTER 6

# Quaternary – climate and processes



LOCATION: 22.8669444N, 59.2341667E 

# Traces of tsunami

VISUAL APPEAL:



SCIENTIFIC APPEAL:



**The rocky coast of the Sea of Oman**



**Imbrication of limestone blocks**



**Boring in limestone blocks**

Along the coast, on the edge of the cliffs, we can observe angular blocks of considerable size (up to several meters long). They are located several meters above the current sea level and several dozen meters away from the shoreline. Lithologically, they mainly represent Eocene limestones. They are karstified and show evidence of bioerosion. They are covered with sessile marine fauna, mainly represented by oysters, scaphopods, gastropods, bryozoans (moss animals), coral fragments, and borings of bivalves from the genus *Lithophaga* sp.

The shape of the blocks, their position on a relatively “cleaned” rocky-shore surface, as well as their inclined arrangement one on top of another (imbrication) and the rotation of the blocks (indicated by the inverted position of the bioeroded surfaces), suggest that they transported as a result of storm-wave or tsunami activity. Given their considerable size compared to storm-wave deposits observed today, one may lean toward the hypothesis that this is a record of an ancient tsunami.

Tsunamis in this region may be related to earthquakes originated along the Makran Subduction Zone in Iran-Pakistan, which forms the northern boundary of the Arabian Plate.

SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

LOCATION: 52.123 N, 34.123 E

25

# Fossil coral reefs

VISUAL APPEAL:



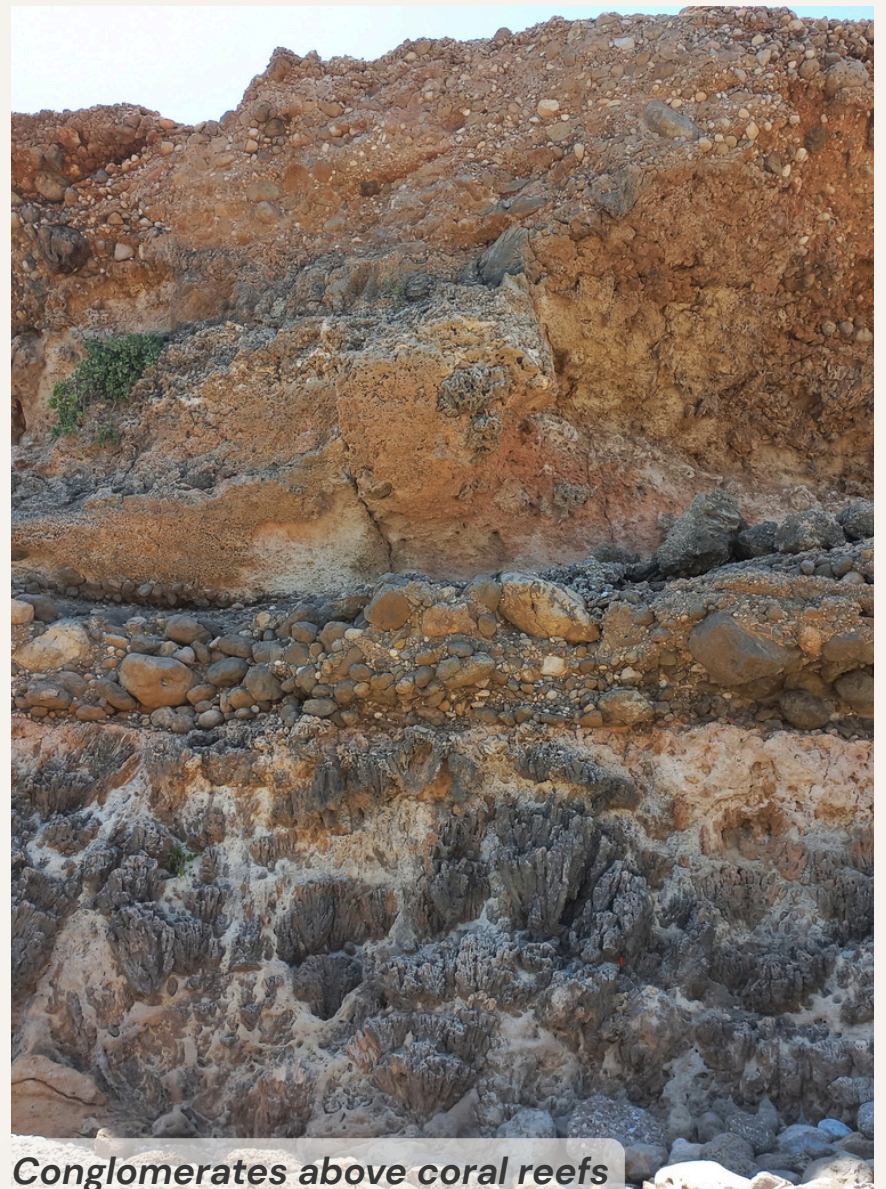
SCIENTIFIC APPEAL:



Along the coast we can observe a series of marine terraces — platforms uplifted Eocene limestones. Their origin is linked to fluctuations in sea level and vertical movements of the Earth's crust, which together controlled the uplift of the terraces. The terraces are incised by wadi valleys, resulting in a cliff profile that exposes alternating marine and terrestrial Quaternary deposits, developed as successive layers of coral-reef facies and conglomerates.

The corals are preserved in life position. Their skeletons show strong branching, and the pore spaces between them are filled with fine-grained clastic sediment, indicating an intensive supply of material from the land.

These deposits contain numerous traces of biological activity, including borings made by rock-boring organisms.



*Conglomerates above coral reefs*



*Fossil coral reefs*

The coarse-grained conglomerates are of fluvial origin, associated with episodic rivers flowing through the wadi valley and depositing material during high-energy events.

This sedimentary succession provides a unique record of eustatic changes and neotectonic activity influencing sea-level fluctuations during the Quaternary.

## SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

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LOCATION: 23.6191106N, 58.4807431E 

# Mangrove forest

VISUAL APPEAL:



SCIENTIFIC APPEAL:



The mangrove forests (mangroves) in Oman represent an extremely important, though small, coastal ecosystem. They are a key element of biodiversity and coastal protection in this desert country. Despite their small size, they fulfill crucial ecological functions. Their complex root systems stabilize the shoreline, reduce erosion, and form a natural barrier that protects against the effects of tropical storms and cyclones that regularly strike the Omani coast.

They are exceptionally important breeding and feeding grounds for many marine and coastal species. They provide shelter for numerous species of birds, fish, crustaceans, and molluscs. The mangroves are also a key habitat for birds, including both resident and migratory species.



*Halophytic shrubs Salicornia sinus-persica*



*Aerial breathing roots (pneumatophores) of the grey mangrove (Avicennia marina)*



*River mouth in the Qurm Nature Reserve*

The Qurm Nature Reserve, located in the heart of Muscat, is one of the largest and most important natural mangrove areas in the eastern part of the Arabian Peninsula. It has been recognised as a Ramsar Convention site (of international importance for wetlands). The Qurm Reserve is an estuary and wetland area situated around the mouth of Wadi Aday. It consists of beaches, coastal dunes, tidal and alluvial flats, where fresh and salt waters mix.

SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

## CHAPTER 7

# The Aflaj Irrigation System



LOCATION: 22.9230292N, 57.6678419E

18

# Irrigation channels

VISUAL APPEAL:



SCIENTIFIC VALUE:



An old Omani proverb says: “Live by the water and do not worry about your livelihood”. This was known nearly 4,500 years ago. It is believed that while the first pyramids were being built in Egypt, the idea of creating a system of irrigation channels — collectively known as aflaj — was born in the Kingdom of Magan (modern-day Oman). The word aflaj comes from Arabic; it is the plural of falaj, which means “to divide into equal parts”. The idea behind the channels was that the water flowing through them should be divided equally. Two assistants to the overseer always watched over the fair distribution, unaware that they were laying the foundations of sustainable resource management.

The aflaj system was built using gravity and the varied terrain. At first, water was drained from wadis activated by rainfall. Only later did people learn to make use of underground sources, from which water flowed directly to cultivated fields and household compounds. The dry lands that once struggled with drought were replaced by oases, and the inhabitants’ quality of life improved. Protecting and restoring the channels was in the interest of local communities, which further strengthened social bonds.



*An irrigation channel, part of the aflaj system*

It is estimated that 3,017 aflaj are still functioning today, with a total length of 2,900 km. Water distribution among the communities, just as it was centuries ago, takes place in a water cycle (from 5 to 21 days). With one essential difference: the stargazing and sundials once necessary for tracking the cycles have now been replaced by a smartphone.

SOURCES:

<https://podroze.onet.pl/ciekawe/systemy-nawadniania-typu-afladz-oman-unesco-informacje-zasada-dzialania/vxqvf2> (access 25.09.2025)

Bandyopadhyay, S., & Mershen, B. (2022). Falaj communities in Oman: A case for local governance? *Journal of Material Cultures in the Muslim World*, 3(1), 6–47. <https://doi.org/10.1163/26666286-12340028>

[https://pl.wikipedia.org/wiki/Systemy\\_irygacyjne\\_aflad%C5%BC\\_w\\_Omanie](https://pl.wikipedia.org/wiki/Systemy_irygacyjne_aflad%C5%BC_w_Omanie) (access 25.09.2025)

PALM GROVES: 22.9225961N, 57.6771150E

19

ABANDONED TOWN: 22.9252017N, 57.6734483E

20

# Birkat al Mawz

VISUAL APPEAL:



SCIENTIFIC VALUE:



During its heyday, the settlement was considered prestigious due to its location. The houses built here were often two-storey and richly decorated. The residents were generally more affluent. From the second half of the 20th century, after a series of bombings carried out during the so-called Mountain War, some of the homes were abandoned forever. Many roofs collapsed. The last inhabitants of Harat al Sibani left the village for larger cities during the wave of modernisation and infrastructure development in the 1990s.



*Birkat al Mawz*



*Date palm groves with a view of the anticline*

One of the places where we can still see a functioning falaj is Birkat al Mawz. In 2016, the local system of irrigation channels, together with four others scattered across various parts of Oman, was added to the UNESCO World Heritage List.

Birkat al Mawz is often called the “banana lake” by Omanis — a name that aptly reflects the atmosphere created by the abundant palm groves. Among the cultivated species, banana trees and date palms dominate, with the latter’s fruit typically being dried. Rising above the green palm canopies are dome-shaped platform limestones forming a picturesque anticline, at the foot of which stand the ruins of a 17th-century abandoned town — Harat al Sibani.

## SOURCES:

[https://pl.wikipedia.org/wiki/Systemy\\_irygacyjne\\_aflad%C5%BC\\_w\\_Omanie](https://pl.wikipedia.org/wiki/Systemy_irygacyjne_aflad%C5%BC_w_Omanie) (access 25.09.2025)

<https://idziemydalej.pl/birkat-al-mouz-bananowe-jezioro/> (access 25.09.2025)

Shankar, R., & Sebastian, S. (2019). Traditional settlements at Birkat-al-Mouz, Oman: Heritage study and documentation. University of Nizwa.

**CHAPTER 8**

# Architecture and construction



CAR PARK: 23.2125867N, 56.9620564E  
 LOCATION: 23.2164892N, 56.9620461E

21



# Jebel Misht: Bronze Age tombs

VISUAL APPEAL:



SCIENTIFIC VALUE:



*Bronze Age tombs and Mount Jebel Misht*



Near Jebel Misht lies a cluster of Tombs of the Ayn — circular, beehive-shaped stone tombs. It is the best-preserved of the three sites of this type in Oman inscribed on the UNESCO World Heritage List in 1988, alongside the tombs at Bat and Al-Khutm. Since 1980 these sites have been legally protected by the Sultanate of Oman.

The mountain visible in the photo, Jebel Misht, is an example of an “Omani exotic” — an isolated limestone massif that stands out lithologically from the surrounding rocks. It is composed mainly of shallow-marine Triassic reef limestones. These rocks are interpreted as remnants of reefs that formed on the summit of a guyot, the eroded top of a submarine volcano located several kilometres off the ancient Arabian continental margin. This and other exotic blocks do not form continuous units; instead, they were “inserted” between surrounding geological formations during tectonic processes. Jebel Misht is therefore a remarkable example of ancient marine and tectonic processes in the region.

At present, no conservation or protective measures are being carried out in the Al-Ayn area. A real threat to the site is the use of stones from the tombs by local communities for their own purposes.

## SOURCES:

<https://whc.unesco.org/en/list/434/> (access 12.09.2025)  
 Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.  
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<https://doi.org/10.1144/SP392.2>

LOCATION: 22.7876661N, 57.5989019E

22

# Harat Al Bilad

VISUAL APPEAL:



SCIENTIFIC VALUE:



Harat Al Bilad is a walled ruin of an ancient town located in the Manah oasis. It is an example of a fortified city surrounded by stone and brick walls. It could be entered through four gates, of which the northern gate (Bab Al-Burj) and the southern gate (Bab Al-Nasr) were guarded by tall stone towers.

Before the Omani Ministry of Heritage and Culture began conservation efforts in the early 21st century, the city of Harat al Bilad was deserted and fell into ruin. Currently, conservation work is being carried out on the northern gate, three mosques, and selected houses. No significant conservation work is being carried out in other parts of the city.



*The abandoned town of Harat al Bilad*



*The abandoned town of Harat al Bilad*

The material used to construct the buildings of Harat Al-Bilad comes almost entirely from local sources. The walls of the houses and defensive walls were built from limestone from the nearby Al-Hajar Mountains, bound together with mortar made from mud and clay obtained from a nearby oasis. Looking closely at the walls, you can see tiny snail shells in them. The clay bricks were dried in the sun, which gave them a characteristic warm color and good thermal insulation.

SOURCES:

<https://haratalbiladmanah.co.uk> (access 09.09.2025).

LOCATION: 22.9644442N, 57.3007125E

23

# Bahla Fort

VISUAL APPEAL:



SCIENTIFIC VALUE:



Oman is sometimes called the country of a thousand forts – and for good reason. In almost every city and oasis, you can find the remains of old fortifications, which for centuries served not only defensive but also administrative functions. They were the centres of local government, protected trade routes and settlements from invasions, and controlled access to water sources.

One of the most important and best-preserved structures of this type is Fort Bahla, located at the foot of the Jebel Akhdar massif in the northern part of the Al-Hajar Mountains. This fort was the first Omani monument to be inscribed on the UNESCO World Heritage List in 1987, which highlights its unique historical and architectural significance.



*Bahla Fort – the UNESCO World Heritage Site*

The entire complex covers an area of several hectares and is surrounded by massive walls approximately 13 km long, built of compacted clay, which encompass both the fort itself and the adjacent buildings of the oasis. Its watchtowers, massive gates, and system of internal courtyards, which served residential, storage, and religious functions, are characteristic features. Within the fort, there is also a mosque and the remains of former workshops and utility rooms.

SOURCES:

<https://whc.unesco.org/en/list/433> (access: 12.09.2025).

<https://www.onceinalifetimejourney.com/once-in-a-lifetime-journeys/middle-east/visiting-bahla-fort-omans-only-unesco-fort> (access: 13.09.2025).

## CHAPTER 9

# Sustainable tourism



WAHIBA SANDS DESERT: 22.3854689N, 58.7051306E

14



4WD REQUIRED

## Tourism in desert areas

VISUAL APPEAL:



SCIENTIFIC VALUE:



Bedouin village

Travelling across the Wahiba Sands can be done in several ways that allow visitors to explore the desert and experience its unique landscape. The most popular options include off-road trips in 4x4 vehicles or quad bikes over the dunes, walks and trekking routes through the desert, as well as camel rides. It is the latter that offer the closest contact with the traditional lifestyle of the Bedouins, allowing visitors to feel the authentic atmosphere of the desert while traversing areas inaccessible to motor vehicles.

For local residents, especially Bedouin tribes, camel tours have become an important source of income. They often also offer overnight stays in traditional tented camps. This allows them to support their families, promote their traditional lifestyle and craftsmanship, and preserve local cultural customs in the face of growing tourist interest. In practice, this form of tourism integrates the natural experience with support for the local community, in line with the principles of sustainable development.



Bedouin village

SOURCES:

Al-Oun, S., & Al-Homoud, M. (2008). The potential for developing community-based tourism among the Bedouins in the Badia of Jordan. *Journal of Heritage Tourism*, 3(1), 36–54. <https://doi.org/10.1080/1743873X.2008.9701249>

LOCATION: 22.4214483N, 59.8344589E

24

# Sea Turtle Reserve

VISUAL APPEAL:



SCIENTIFIC VALUE:



Ras Al Jinz, located on the easternmost tip of Oman along the Arabian Sea, is one of the most important nesting sites for the green turtle in the world. Thousands of females return here every year to lay their eggs in the soft beach sand. The reserve, established in 1996, is part of the larger Ras Al Jinz Turtle Reserve and represents a combination of science, nature conservation, and ecotourism.

Oman has long been aware of the importance of its beaches for marine turtles. The first research conducted at Ras Al Jinz began in the 1970s, and in 1982 the region gained international recognition thanks to the report by J.P. Ross and M.A. Barwani. Since then, Oman has become a regional leader in turtle conservation, developing monitoring and education programs. The reserve is often mentioned as a potential candidate for the UNESCO World Heritage List.

*A green sea turtle lit by red light*



*A green sea turtle lit by red light*



The main attraction of this site is the nighttime guided observation of the turtles. Unfortunately, the large number of tourists on a relatively small stretch of beach can stress the animals and may even lead to them being accidentally stepped on by visitors.

Guides try to reduce the negative impact of humans by prohibiting the use of flash photography, but the mere presence of large groups and their equipment can still be burdensome for the turtles. Tracks in the sand suggest that some females abandon nesting when people are nearby.

Although the concept of the site was built on protecting turtles, in practice the challenge remains finding a balance between tourism and the needs of these remarkable animals.

SOURCES:

<https://www.rasaljinz-turtlereserve.com> (access: 01.09.2025).  
<https://whc.unesco.org/en/tentativelists> (access: 01.09.2025).

# Mindful beachgoing

The beaches of Oman are not only places for relaxation but also complex ecosystems. Between the dunes and the surf zone live sea turtles, crabs, terns, small crustaceans, molluscs, and plants adapted to salty, shifting sands. Coastal rocks are covered with characteristic barnacles, accompanied by oysters, cone-shaped *Patella* gastropods, and dark massive chiton shells. The sand is rich in fragmented shells, whole shells of bivalves and gastropods, and occasional pieces of coral skeletons or sponges. In areas periodically covered by water, sea anemones can also be observed.

This delicate web of interactions is easy to disturb. Even a few dozen people walking after dark can destroy crab burrows or areas where fish and turtles lay their eggs. For this reason, Oman strictly prohibits flash photography, disturbing wildlife, and leaving waste. Visitors are encouraged to stay on designated paths, avoid approaching wading birds and crab burrows, and reduce artificial light at night.



*Barnacles (pink), chitons (dark) and oysters (upper left corner)*



*A crab encountered on an Omani beach*

Limiting noise and using biodegradable cosmetics also directly supports the health of the ecosystem. In protected areas such as Ras Al Hadd or Khawr Al Baleed, conservation is combined with education.

Mindful beachgoing is above all about awareness — recognizing that beneath a seemingly simple landscape lies a world full of life. Understanding that we are guests in nature's space changes the way we move through it. Respect for plants and animals, quietness, and leaving no litter are the simplest ways to care for the places that welcome us.

## SOURCES:

<https://whc.unesco.org/en/tentativelists/5840/> (access: 30.10.2025).

LOCATION: 24.1852989N, 56.3153869E

25



4WD REQUIRED

# Mineral springs

VISUAL APPEAL:



SCIENTIFIC VALUE:



Ain Sahban is a unique hyperalkaline spring located in the Al Batinah region, near the city of Suhar in Oman. The waters of the spring emerge within a wadi cutting through the Samail Ophiolite Massif, where the surrounding rocks consist mainly of gabbros and ultramafic igneous rocks. The cations in the water may originate from the natural dissolution of these rocks through which the water flows. Minerals present in them, such as olivine, enstatite, diopside and plagioclase, release magnesium, calcium and sodium ions into the solution when interacting with water and  $\text{CO}_2$ . As the water moves through the rock, it undergoes mineralisation, which leads to the appearance of cations characteristic of this type of geological environment.

The spring is located in mountainous terrain within a wadi valley, and access to it is via an unpaved road, which may pose some difficulty for visitors.

This place has significant tourist potential, especially for nature lovers and adventure seekers. The uniqueness of these springs can attract tourists interested in ecotourism, nature photography and relaxation in a natural setting.

Currently, the area is not highly developed in terms of tourist infrastructure, which can be both an advantage and a challenge.



*Turquoise mineral pool*



*Precipitation of carbonates in the form of travertine*

SOURCES:

Hoffmann, G., Meschede, M., Zacke, A. Kindi, M. (2016). Field Guide to the Geology of Northeastern Oman. Borntraeger Science Publishers.

LOCATION: 22.5616947N, 59.5367153E

26

# Port of Sur

VISUAL APPEAL:



SCIENTIFIC VALUE:



For centuries, Sur was one of the most important seafaring centres in Oman. From here, for hundreds of years, trading ships departed for India, East Africa, and even China. The port served as a hub for the trade of frankincense, dates, spices, and timber. Today it functions mainly as a local fishing harbor, but it has preserved its traditional atmosphere – you can still see dozens of fishing boats and feel the spirit of a historic coastal town.

A particular attraction of Sur is its old shipyard, where traditional dhow boats are still built – without nails, using only wooden pegs and ropes. It is a unique place, as this craft has nearly disappeared elsewhere. In the shipyard, visitors can observe the entire process of building a boat (most often from imported teak and mahogany).



*A man working on a component of a dhow*



*The wooden frame of a boat under construction*

Next to the shipyard operates a small museum dedicated to the history of Omani seafaring. Its collection includes models of various types of dhow boats, traditional shipbuilding tools, maps of historic trade routes, and photographs documenting Sur's maritime past. The main attraction is a full-sized dhow open to visitors – you can step on board and experience the atmosphere of ancient sea voyages.

While walking through the museum and its surroundings, it is also worth paying attention to what lies under your feet. These are, in fact fragments of coral skeletons!

## SOURCES:

<https://patrimoinedorient.org/index.php/en/homepage-3/> (access: 21.09.2025).  
<https://www.oman.de/en/society/culture/crafts/shipbuilding> (access: 21.09.2025).

# Conclusions

## OMAN EMERGES AS A UNIQUE NATURAL LABORATORY WHERE GEOLOGY, CLIMATE, AND CULTURE INTERTWINE

Oman is a land of impressive natural processes – from erosion sculpting monumental canyons, through karst caves and desert dunes, to the remnants of ancient seas and continental collisions recorded in the rocks. On the other hand, it is a space where people have, for centuries, learned to use limited water and energy resources, creating sustainable solutions such as the aflaj irrigation systems.

In the face of intensifying climate change, Oman faces challenges similar to those of many regions around the world: water scarcity, the risk of natural disasters, and the pressures of mass tourism. The answer to these challenges may lie in the development of geotourism and ecotourism, which not only minimize the negative impact of travel on the environment but also raise environmental and social awareness among visitors.

This guide is part of that idea – it serves as both an educational tool and an inspiration for responsible exploration of the world. It shows that travel can be more than just the consumption of attractions: it can become an act of care for the environment and a way to build bridges between culture, science, and nature.

The lessons drawn from Oman's experience indicate that sustainable tourism offers a genuine opportunity for harmonious development – for both local communities and the natural environment. It is within an interdisciplinary approach, combining geological, biological, climatic, and social sciences, that the key lies to better understanding and protecting our planet. Oman stands as living proof that it is possible to reconcile tourism development with the preservation of natural and cultural heritage – a message of truly universal value.

*Trail in Wadi Ghul*



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