The Sorbas Basin

Geological Features
Geological Features and Evolution

Geological Map of the Sorbas Basin

GEOLOGICAL CONTEXT OF THE SORBAS BASIN

Sierra de Gádor

Almería

Carboneras

NW SE

Sierra de los Filabres

Sierra Alhamilla

Gypsum karst

Río Aguas

Vera

Níjar

Cabo de Gata

Neogene sediments

Neogene volcanic rocks

Betic Substratum

Modified from Montenat, 1990

Graphic Scalebar

GEOLOGICAL SECTION

Sorbas

5 Km

Position of geological section

Uleila

Turrillas

Lucainena

CABRERA

ALHAMILLA

SIERRA DE LOS FILABRES

5 Km

Geological Section of the Sorbas Basin

STRATIGRAPHY OF THE SORBAS BASIN

1.8

5.3

5.9

6.2

7.1

QUATERNARY

PLIOCENE

MESSINIAN

Tortonian

PRE-MIOCENE

Conglomerates and sands

Bioclastic sands

Conglomerates, sands and muds

Conglomerates, oolites, patch reefs and stromatolites

Sands and muds

Gypsum

Marls

Conglomerates, oolites, patch reefs and stromatolites

Conglomerates and red sands

Betic Substratum. Metamorphic rocks: phyllites, schists, quartzites, marbles, etc...

10

9

8

7a

7b

6

5

4b

4a

3

2b

2c

2a

1

Conglomerates and sands

Bioclastic limestones

Marls, sands and conglomerates

Reefal limestones

Conglomerates and red sands

Conglomerates and sands

Bioclastic sands

Conglomerates, sands and muds

Conglomerates, oolites, patch reefs and stromatolites

Sands and muds

Gypsum

Marls

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Conglomerates and red sands

Betic Substratum. Metamorphic rocks: phyllites, schists, quartzites, marbles, etc...
At the end of the Miocene (around 5.5 million years ago, during the Messinian) an enhanced process of desiccation of the Mediterranean Sea caused the marine Sorbas Basin to become practically dry, with a very shallow depth subjected to strong evaporation. In these circumstances a package of gypsum almost 100 metres in thickness was deposited: the Sorbas gypsum. Afterwards, the sea reoccupied its level, continuing the accumulation of marls and detrital sediments above the gypsum, up until, around 3.5 million years ago (in the Pliocene), the Sorbas Basin constitutes an intermontane basin of singular geological interest for the study and understanding of palaeogeographical and palaeoenvironmental changes occurring on the Mediterranean coast during the last 8 million years, and its relationship to the geological evolution of the Betic Cordillera.

Eight million years ago (in the Upper Miocene), the configuration of land emerged and submerged beneath the sea along the coastal zone of Almería was similar to present, but not identical: the sea spread across the Sorbas Basin, dry land today, up to the foothills of the Sierra de los Filabres, in whose margin reefs of fossil corals from this age remain as testament, closely marking the position of the ancient coastline. On the slopes, submarine fans deposited thick and extensive sediments that the rivers stripped out from the emergent relief. The later emergence of Sierra Alhamilla and Sierra Cabrera configured a long and narrow intermontane marine basin between these new relieves, to the south, and Los Filabres, towards the north, where the deposition of marine sediments continued: this is today called the Sorbas Basin.

Geological Features and Evolution

The Sorbas basin constitutes an intermontane basin of great palaeogeographical interest for the study and understanding of palaeogeographical and palaeoenvironmental changes occurring on the Mediterranean coast during the last 8 million years, and its relationship to the palaeogeological evolution of the Betic Cordillera.

Around 5.5 million years ago (in the Messinian), due to tectonic uplift, the Mediterranean Sea disconnected from the Atlantic Ocean, and evaporites (gypsum and salt) were deposited in its central and deepest region. The thickness of accumulated salt locally exceeds 1300 m in some places, related to the phenomenon of important deposits of evaporites deposited in the Sorbas Basin, which locally exceed 150 m in thickness and that outcrop over an area of nearly 25 square kilometres.

Table: SEDIMENTARY INTERPRETATION FOR THE SORBAS GYPSUM IN A MEDITERRANEAN CONTEXT

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
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<tbody>
<tr>
<td>(5.5 Ma bp)</td>
<td>Around 5.5 million years ago the Mediterranean Sea dried up due to tectonic uplift.</td>
</tr>
<tr>
<td>(5.9 Ma bp)</td>
<td>Situated prior to the deposition of evaporites, with the formation of reefs along the margins and marly-muddy sediments in the basin.</td>
</tr>
<tr>
<td>(5.5 Ma bp)</td>
<td>Sediments deposited on the continental shelf with the Atlantic Ocean during the Messinian.</td>
</tr>
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<td>Desiccation of the Mediterranean Sea. Evaporites deposits in the central and deepest region.</td>
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The final retreat of the sea meant that the marine sediments became exposed to the action of erosive agents. The removal of the upper sedimentary layers left the highly soluble gypsum subjected to the continuous action of water, which progressively dissolved it. Therefore, one of the most important gypsum karst landscapes in the world, for its size, worth and beauty started to form.
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STRATIGRAPHY OF THE SORBAS BASIN

1. **Betic Substratum.** Metamorphic rocks: phyllites, schists, quartzites, marbles, etc...

2. **Pre-Miocene**
   - 2a Conglomerates and red sands
   - 2b Reefal limestones
   - 2c Marls, sands and conglomerates

3. **Messinian**
   - 3 Bioclastic limestones

4. **Pliocene**
   - 4a Calcarenites
   - 4b Fringing reefs

5. **Quaternary**
   - 5 Marls

6. **Quaternary**
   - 6 Gypsum

7. **Miocene**
   - 7a Conglomerates, oolites, patch reefs and stromatolites
   - 7b Sands and muds

8. **Pre-Miocene**
   - 8 Conglomerates, sands and muds

9. **Quaternary**
   - 9 Bioclastic sands

10. **Quaternary**
    - 10 Conglomerates and sands

Millions of years:
- 1.8
- 5.3
- 5.9
- 6.2
- 7.1

50 m
Geological Features and Evolution

GEOLOGICAL MAP OF THE SORBAS BASIN

GEOLOGICAL CONTEXT OF THE SORBAS BASIN

GEOLOGICAL SECTION
PALAEOGEOGRAPHICAL EVOLUTION OF THE SORBAS BASIN FROM THE UPPER Tortonian (8 Ma) TO THE LOWER Pliocene (4 Ma)

A. UPPER Tortonian (around 8 Ma)

B. END Tortonian-Lower Messinian (around 7 Ma)

C. LOWER Messinian (around 6 Ma)

D. UPPER Messinian (evaporitic unit, around 5.5 Ma)

E. UPPER Messinian (around 5.4 Ma)

F. Pliocene Inferior (around 4 Ma)
Around 5.5 million years ago (in the Messinian) the Mediterranean dried up through closure of its communication with the Atlantic Ocean due to tectonic uplift, and masses of evaporites (gypsum and salt) were deposited in its central and deepest region. The thickness of accumulated salt (mainly sodium chloride) exceed 1500 m in some places. In relation to this phenomenon, important deposits of gypsum (hydrated calcium sulphate) were also deposited in the Sorbas Basin, which locally exceed 130 m in thickness and that outcrop over an area of nearly 25 square kilometres.

**SEDIMENTARY INTERPRETATION FOR THE SORBAS GYPSUM IN A MEDITERRANEAN CONTEXT**

Situation prior to the deposition of evaporites, with the formation of reefs along the margins and marly-muddy sediments in the basin.

Evaporite deposits in the centre of the Mediterranean result from this disconnection with the Atlantic, and drying out.

Evaporite deposits in the interior of the Sorbas Basin.
The gypsum deposits in the Sorbas Basin were not, however, strictly contemporaneous with the deposition of evaporites in the centre of the Mediterranean, but somewhat later. This deposition took place during the reflooding phase of the Mediterranean, upon refilling with new water, presumably coming from the Atlantic and invading a broad semi-restricted depression, that at the time occupied a large part of what today constitutes the Sorbas Basin.

The Sorbas gypsum was deposited in an evaporitic basin, of restricted character, closed towards the west and separated from the open sea by a submarine barrier located at its most easterly end, created through uplift of the Sierra Cabrera.
In detail, the evaporite sequence of Sorbas consists of banks of gypsum, of up to 20 m thickness, separated by marly-limestone intervals and/or carbonates. The thickness of the gypsum banks diminishes towards the top at the same time as that of the non-evaporitic intervals increases. The latter, at least in the higher part, possess a marine character, in that they incorporate the remains of the calcareous skeletons of marine organisms and record the different episodes of basin inundation.

In the highest banks of gypsum in the sequence a very spectacular growth structure of arborescent character evidently forms, known as supercones (also called cauliflowers), that are interpreted as resulting from competition between the growth of gypsum and the deposition of contemporaneous muddy sediments.
Rainwater and groundwater are capable of dissolving soluble rocks in a slow process that takes thousands of years. The resultant landscape, known as karst or karstic landscape, is very peculiar. It is characterised by the presence of abundant closed depressions at the surface (dolinas, potholes, etc.) and a complex subterranean drainage system (cavities).

Karstification of gypsum is an infrequent phenomenon in nature. The greater part of known karst are limestones. The Sorbas karst is the most important gypsum karst in Spain, and one of the four best known examples in Europe. Additionally, it has a very high scientific and didactic value in a world context.

FEATURES IN KARST LANDSCAPE

1. Tepuys (Karst en cuarcitas)
2. Pitons, Stacks, Towers (tropical karst)
3. Lapiés/Karren (high mountain karst)
4. Dissolution Dolina
5. Uvala
6. Polje
7. Ponor
8. Collapse dolinas
9. Rock bridge
10. Joint
11. Sinkhole
12. Pothole
13. Chimney
14. Cascade
15. Bedding Plane
16. Pipe
17. Sump
18. Debris cone
19. Gours
20. Fossil Gallery
21. Lake
22. Column
23. Resurgence
24. Dry valley
25. Trop Plein
26. Cave
27. Canyon

Zone of recharge (photo J.M. Calaforra).
Zone of transfer (photo J.M. Calaforra).
Flooded Zone (photo J.M. Calaforra).
How is the gypsum karst of Sorbas formed?

1. The gypsum is originally covered by other sediments, on top of which the incipient drainage network starts to install itself.

2. The drainage network erodes the upper sediments until exposing the gypsum in very localised places where the first dolinas originally start to be dissolved.

3. The gypsum is becoming exposed to a greater extent at the surface through time. A multitude of dolinas develop that favour the entrance of water into the interior.

4. The general entrance of water into the gypsum mass promotes its slow dissolution, creating a complex subterranean network of galleries.
Landscape and surface features

A multitude of small depressions pepper the surface of the karst. These are the dolinas. They result from the dissolution or collapse of the surface layers of the gypsum.

Large gypsum blocks tumble down from the cliff covering the marl slope. These are called block falls.

An escarpment cliff delimits the entire southern margin of the gypsum outcrop.

Above the gypsum rock an extensive karstic plain is fashioned.

The extensive plain, the escarpment cliff and the valley are the most characteristic elements of the surface landscape.

The Río Aguas cuts down towards the south into soft marly sediments giving rise to a broad valley.
Dissolution features: chambers and galleries

Rainwater penetrates into the rock interior, starting to dissolve the gypsum.

Dissolution progressively enlarges the initial channel.

The water penetrates through to the lower layers. The initial crystallization features start to form.

The water infiltrates, slowly dissolving gypsum rock, generating a complex network of subterranean galleries. Chambers are formed from galleries through the dissolution of the walls, and by the fall of blocks from the walls and roof.
Slowly meanders are excavated, on occasions they are very long.

Only the lower section is permanently flooded.
Crystallization features: speleothems

Water infiltrates dissolving the gypsum, is saturated and crystallizes in extremely delicate forms. These are the speleothems.

It has taken hundreds of thousands of years, millions at times, in order for nature to sculpt them. Respect them, never touch them, and be careful not to damage them by accident. They have an incalculable value, but only here where they were born, they have no value elsewhere.

Water circulates through the incipient galleries and chambers, infiltrating and dissolving the gypsum rock.

Gypsum is saturated in this slow process so that it then precipitates in the form of small crystals.

The roof, walls and floors of chambers and galleries are coated with a multitude of gypsum crystals in fanciful designs and colours.

1. **Stalagmites.**
2. **Columns.**
3. **Mamelones.**
4. **Rings.**
5. **Stalagmite mounds.**
6. **Curtains.**
7. **Corals.**
8. **Balls.**