UNESCO-IUGS. IGCP PROJECT Nº 96 MESSINIAN CORRELATION
MESSINIAN SEMINAR Nº 3.- FIELD TRIP Nº 2 (Sorbas)
SEMINARIO SOBRE EL MESSINENSE Nº 3.- EXCURSION Nº 2 (Sorbas)

INTRODUCTION TO THE MIO/PLIOCENE OF THE SORBAS BASIN

H. DRONKERT and H. PAGNIER
Geologisch Instituut.- Nieuwe Prinsengracht 130.- Amsterdam. Holland

Contents:

INTRODUCTION

The Sorbas-basin is part of a system of interconnected intermontane Neogene Basins in the Betic Cordilleras, the Alpine foldbelt of S.Spain. These Betic Cordilleras consist of a series of alpine nappes, from top to bottom:

4. The non-metamorphic Malaguide complex
3. The metamorphic Alpujarride complex
2. The metamorphic Ballabona-Cucharon complex
1. The metamorphic Nevado-Filabride complex

The original sedimentary rocks within these nappes are Paleozoic to Permo-Triassic, extending in the Malaguide Complex upto early Miocene age. After most horizontal (Nappe) movement ceased in the Burdigalian, vertical differential movements played a major role in creating the Neogene basins. (VOLK, 1967).

Only a few erosional rests of the earliest basins (Burdigalian) are now situated along the uplifted borders of the recent intermontane depressions, and are mainly resting on non-metamorphic basement rocks. In the Tortonian erosion and basinfilling followed each other several times. Sediments of the Tortonian basins too, mostly occur along the margins of the recent intermontane depressions, and usually lie directly on metamorphic basement, as most of the nonmetamorphic basement

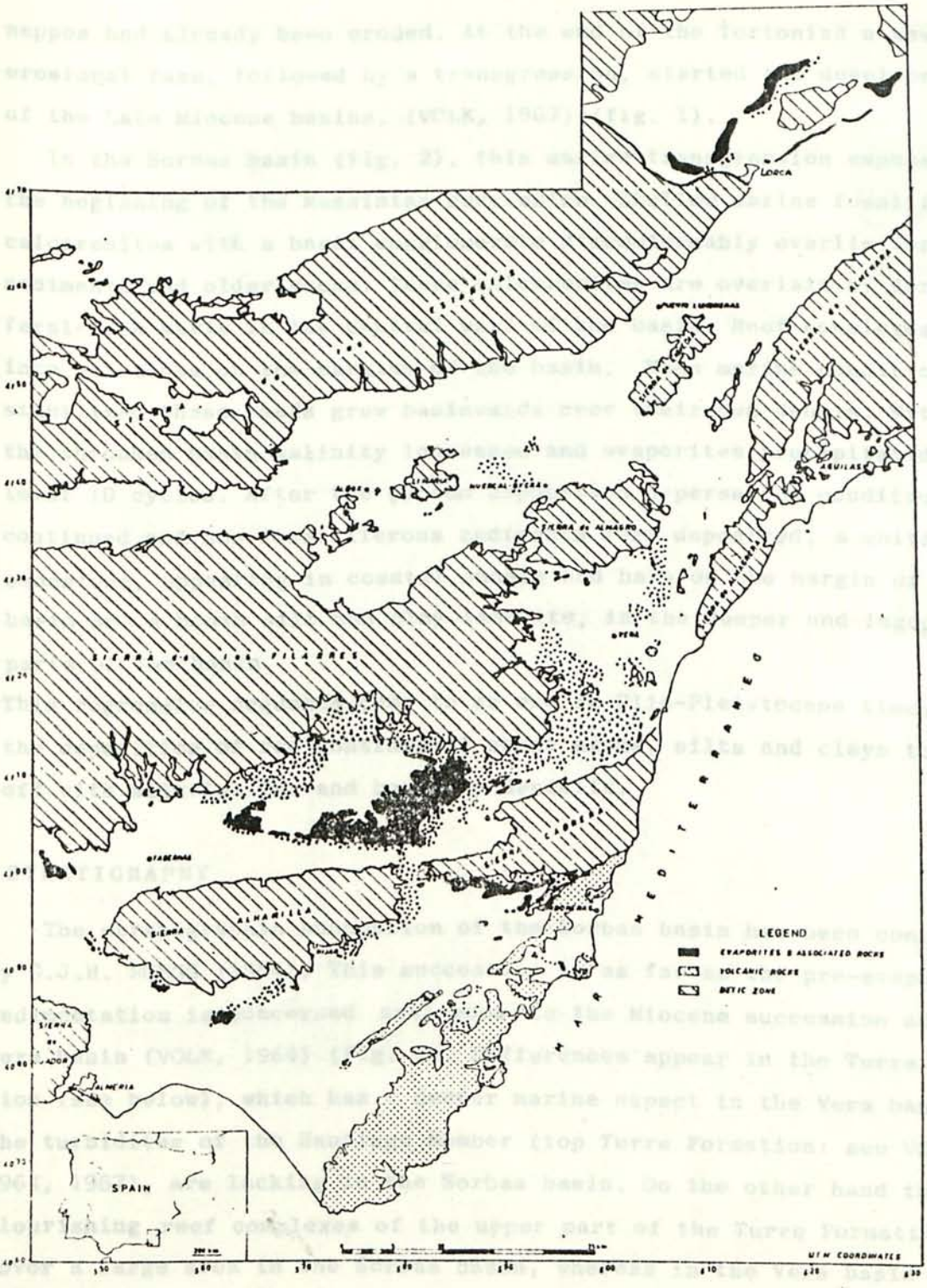


Fig. 1 Map of basement rocks volcanics, Messinian evaporites and other Messinian sediments (dotted).

nappes had already been eroded. At the end of the Tortonian a new erosional fase, followed by a transgression, started the development of the Late Miocene basins. (VOLK, 1967) (fig. 1).

In the Sorbas basin (fig. 2), this marine transgression emphasizes the beginning of the Messinian succession. Shallow marine fossiliferous calcarenites with a basal conglomerate discomformably overlie Tortonian sediments and older rocks. These calcarenites are overlain by foraminiferal-rich marls in the central part of the basin. Reef complexes came into existence on the margins of the basin. When marine conditions stabilized these reefs grew basinwards over their own debris. Within the shrunken basin salinity increased and evaporites precipitated in at least 10 cycles. After the gypsum deposition hypersaline conditions continued and non-fossiliferous sediments were deposited, a white sandstone, appearing in coastal shoals and bars on the margin of the basin and a brown silt and clay laminite, in the deeper and lagoonal parts of the basin.

This regressive sequence came to an end in Plio-Pleistocene times with the deposition of red continental sheet sands, silts and clays topped off with alluvial fan and barranco deposits.

STRATIGRAPHY

The stratigraphic succession of the Sorbas basin has been compiled by G.J.H. RUEGG (1964). This succession is as far as the pre-evaporite sedimentation is concerned analogous to the Miocene succession of the Vera basin (VOLK, 1964) (Fig. 3). Differences appear in the Turre Formation (see below), which has a deeper marine aspect in the Vera basin. The turbidites of the Santiago Member (top Turre Formation: see VOLK 1964, 1967), are lacking in the Sorbas basin. On the other hand the flourishing reef complexes of the upper part of the Turre Formation cover a large area in the Sorbas basin, whereas in the Vera basin the Cantera Member only comprises the regressive remains of a reef complex. After the deposition of the Turre Formation, the stratigraphic

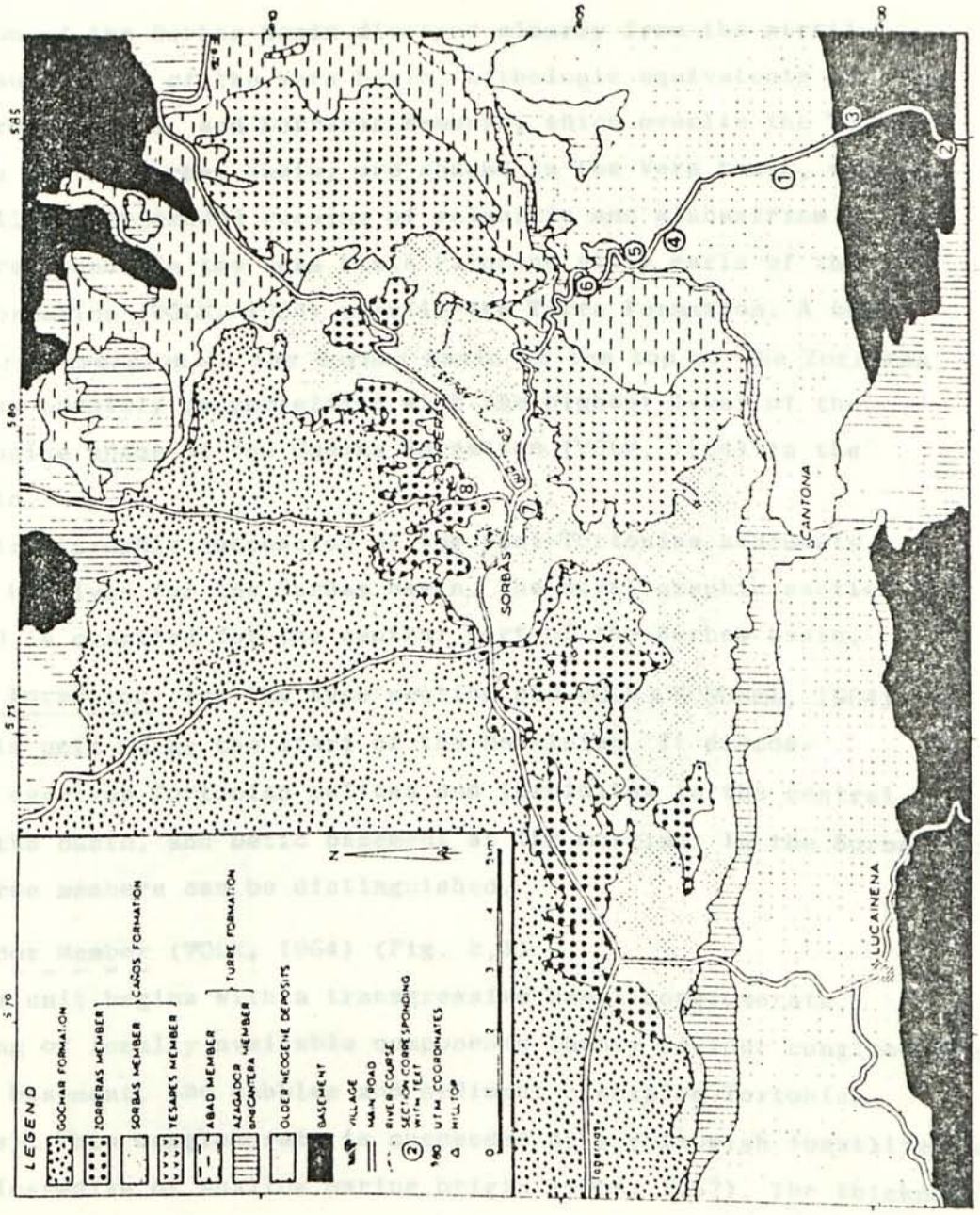


Fig. 2. Geological map and excrusion itinerary of the Sorbas basin.

succession of the Sorbas basin diverged clearly from the stratigraphic succession of the Vera basin. Lithologic equivalents of the Yesares, Sorbas, and Zorreras Members, which overlie the Turre Formation in the Sorbas basin, are absent in the Vera basin, where only small partly eroded remains of selenitic and alabastrine gypsum are found. In the Vera basin Pliocene silty marls of the Cuevas Formation (VOLK, 1964) overlie the Turre Formation. A small marine transgression in the Sorbas basin at the top of the Zorreras Member may possibly be correlated with the highest level of the transgressive phase of the Cuevas Formation (VOLK, 1964) in the Vera basin.

The stratigraphic succession of the post-Tortonian sediments will now be given for the Sorbas basin. The stratigraphic section of Fig. 3 is compiled for the central part of the Sorbas basin.

1. TURRE Formation (for the type section see VOLK & RONDEEL, 1964) -

- This unit marks the start of the Messinian. It disconformably overlies Tortonian pelites and turbidites in the central part of the basin, and Betic basement at the margins. In the Sorbas basin three members can be distinguished.

a. Azagador Member (VOLK, 1964) (Fig. 2,3) -

- This unit begins with a transgressive basal conglomerate, consisting of locally available components (heavy boulder conglomerates on Betic basement, and pebbles and sediment clasts on Tortonian sediments). This conglomerate is succeeded by a yellowish fossiliferous benthocalcarenite of shallow marine origin (VOLK, 1967). The thickness ranges from 10 m in the centra of the basin to 90 m at the northern margin (Fig. 2). Bryozoans indicate a depth of 20 - 90 m at temperatures above 12° C. (VOLK, 1967). Similar very coarse shelly sands were piston-cored at about 40 m depth in the Strait of Sicily (MALDONADO & STANLEY, 1977).

b. Abad Member (VOLK, 1964) (Fig. 2,3) -

- This unit represents the deeper marine facies equivalent to the

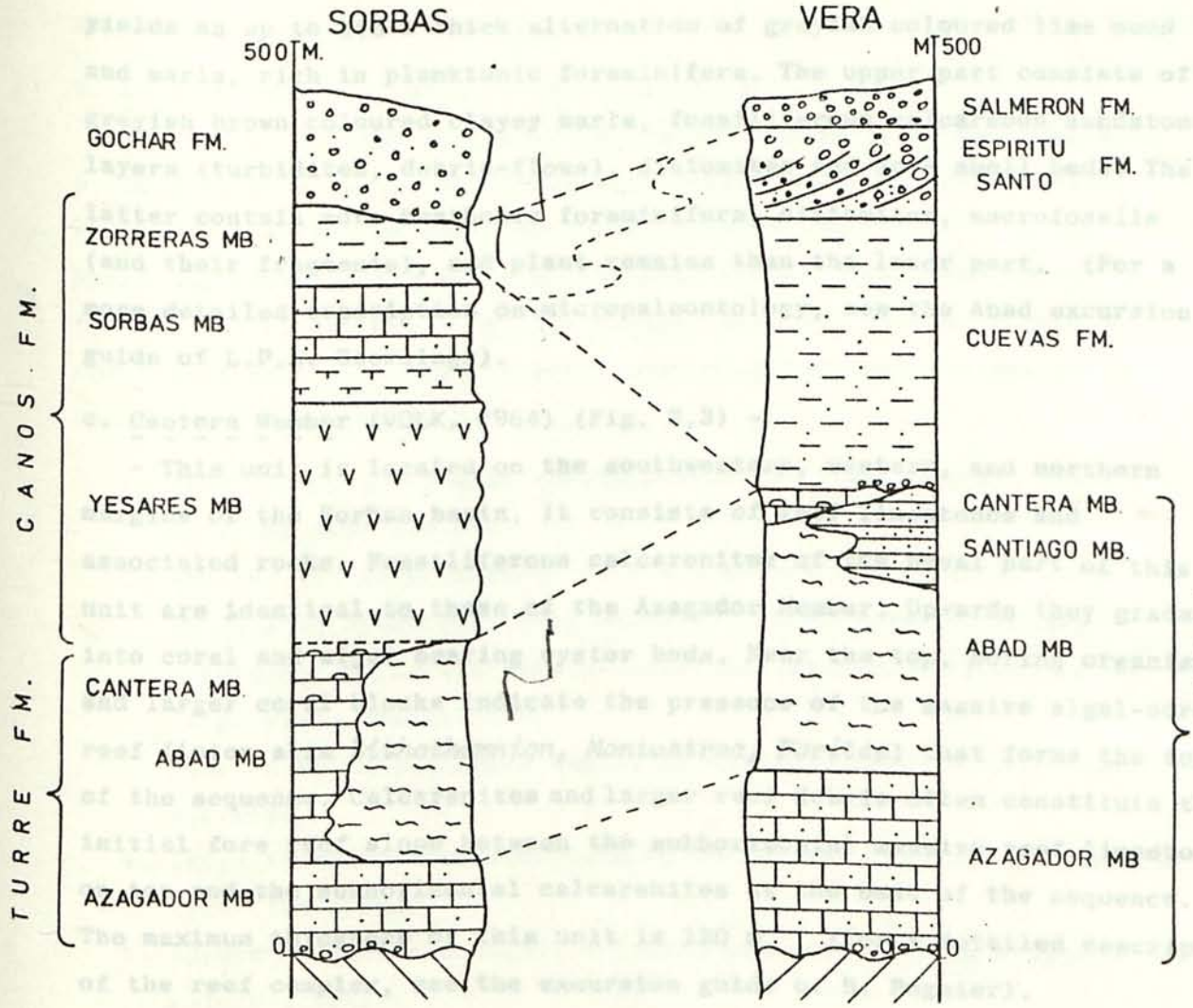


Fig. 3. Composite lithological sections of the Sorbas - and the Vera basin.

Azagador and Cantera Members. The Abad Member overlies the Azagador Member calcarenites and pinches out towards the (Reef) margins of the basin. Rocks of the three Turre Formation members grade laterally and vertically into one another. In the centre of the basin, the Abad Member yields an up to 175 m thick alternation of greyish coloured lime muds and marls, rich in planktonic foraminifera. The upper part consists of greyish brown coloured clayey marls, fossiliferous calcareous sandstone layers (turbidites, debris-flows), diatomites and some shell beds. The latter contain more benthonic foraminifera, diatomites, macrofossils (and their fragments), and plant remains than the lower part. (For a more detailed description on micropaleontology, see the Abad excursion guide of L.P.A. Geerlings).

c. Cantera Member (VOLK, 1964) (Fig. 2,3) -

- This unit is located on the southwestern, western, and northern margins of the Sorbas basin. It consists of reef limestones and associated rocks. Fossiliferous calcarenites of the basal part of this unit are identical to those of the Azagador Member. Upwards they grade into coral and algal bearing oyster beds. Near the top, boring organisms and larger coral blocks indicate the presence of the massive algal-coral reef (inter alia *Lithothamnion, Montastrea, Porites*) that forms the top of the sequence. Calcarenites and larger reef debris often constitute the initial fore reef slope between the subhorizontal massive reef limestone on top and the subhorizontal calcarenites at the base of the sequence. The maximum thickness of this unit is 120 m. (For a detailed description of the reef complex, see the excursion guide of H. Pagnier).

2. CAÑOS Formation (RUEGG, 1964) (Fig. 2,3) -

- Sediments of this unit were not encountered on basement rocks, Tortonian sediments or on marginal deposits of the Turre Formation. This implies that the sediment deposition resulting in the Caños Formation was confined to a small area, the central and deeper part of the former Turre basin. The Caños Formation is subdivided into three members which are from base to top the Yesares, Sorbas and Zorreras Members.

VOLK and RONDEEL (1964) grouped this Yesares Member into the Turre Formation, while RUEGG (1964) defined it as member of the Caños Formation. Considering the great contrast in lithology and fossil content between the normal marine marls of the Turre Formation and the gypsum deposits of the Yesares Member, the authors prefer Ruegg's classification.

a. Yesares Member (RUEGG, 1964) (Fig. 2,3) -

- The type section is located along the Rio de Aguas and comprises a 130 m thick alternation of selenite layers and lime mud laminite. The Yesares Member is confined to the deepest central part of the basin and overlies the marls of the Abad Member. The modal cycle of the 10 - 12 cycles building this Member, consists of 7 m of gypsum and 3 m of pelite. Seven different morphological associations can be recognized, from top to bottom.

7. alternating: carbonate mud, gypsarenites (turbidites), detrital silt and clay laminae.
6. smaller (often prismatic) selenite crystals (cm-size); up to 50 cm long subhorizontally oriented curved selenite twins; supercones up to 4 m high of anastomosing gypsum clusters; large scale undulations.
5. massive selenite layers (cm to dm crystals) with dissolution surfaces.
4. large selenitic (chevron sets up to m-size) crystals in vertical tree-like columns.
3. layers of subhorizontally oriented prismatic gypsum crystals, mainly clastic.
2. selenite nucleation cones, pelitic laminae.
1. laminated microcrystalline gypsum-carbonate-clay alternation.

These morphological associations are partly comparable to the 6 facies of G.B. VAI and F. RICCI LUCCHI (1976). (For a detailed description of the Yesares Member, see the excursion guide of H. Dronkert).

b. Sorbas Member (RUEGG, 1964) (Fig. 2,3) -

- The type section (Fig. 2) in the Rio de Aguas comprises 65 m. The base contains a 20 m thick alternation of brown and yellowish clay and lime mud laminites overlying the evaporites of the Yesares Member. From these laminites a transition is seen towards the white calcareous, sandy and conglomeratic upper part which represents a barrier beach environment. Most obvious is the white colour and absence of fossils except for some burrows in the upper part of the barrier beach complex. In the intercalated lagoonal sediments of the upper part footprints of birds and mammals, mud cracks and plant roots were observed.

c. Zorreras Member (RUEGG, 1964)(Fig. 2,3) -

- This unit consists of 5 to 45 m of reddish brown coloured mudstones and sandstones with some conglomerate layers near the top. The reddish colour and the presence of mud cracks and caliche soils in the basal part point to continental conditions during deposition of the main part of this member. Two thin (75 - 150 cm) white carbonate mud intercalations, with tiny shell debris and a high content ostracodes (*Cyprideis* sp.), probably represent short term transgressions over the extended coastal flats. Near the top a yellowish fossiliferous calcareous sandstone is present. This marine intercalation may correlate with the transgressive phase of the Cuevas Formation (VÖLK, 1964) in the Vera basin. (For a detailed description of the Sorbas and the Zorreras Members, see Th.B. Roep & D. Beets in this guide book).

3. GOCHAR Formation (after RUEGG, 1964) (Fig. 2,3) -

- This unit consists mainly of greyish to reddish coloured conglomeratic to clayey alluvial fan and barranco deposits. It is the youngest formation to be tectonically disturbed.

(Sub)recent alluvial deposits locally overlie the older unit.

REFERENCES

DRONKERT, H.,197 . - Late Miocene evaporites in the Sorbas Basin and adjoining areas. Proceedings 1st Messinian Seminar Erice (Sicily), Oct 1975. (in press).

DRONKERT, H.,1976 - Messinian evaporites in the province of Almeria (SE Spain). Abstracts Messinian Seminar n. 2, Gargnano, Sept., 1976.

MALDONADO, A. & STANLEY, D.J., 1977 - Lithofacies as a function of depth in the Strait of Sicily. Geology, v.5, p. 111-117.

PAGNIER, H.M.J., 197 . - Depth of deposition of Messinian selenitic gypsum in the basin of Sorbas (SE Spain). Proceedings 1st Messinian Seminar Erice (Sicily)., Oct 1975 (in press).

RUEGG, G.J.H., 1964 - Geologische onderzoekingen in het bekken van Sorbas, S.E. Spanje. Internal report Geol.Inst. Univ.Amsterdam, 67 p.

VAI, G.B. & RICCI LUCCHI, F., 1976 - The Vena del Gesso Basin in Northern Apennines. Excursion guide Messinian Seminar no. 2, Gargnano September 5-12, 1976.

VOLK, H.R. & RONDEEL, H.E., 1964 - Zur Gliederung des Jungtertiairs im Becken von Vera Südostspanien. Geol.Mijnbouw, 43, 310-315.

VOLK, H.R., 1967 - Zur Geologie und Stratigraphie des Neogenbecken von Vera, Südost-Spanien. Thesis, Univ. Amsterdam, 164 p.

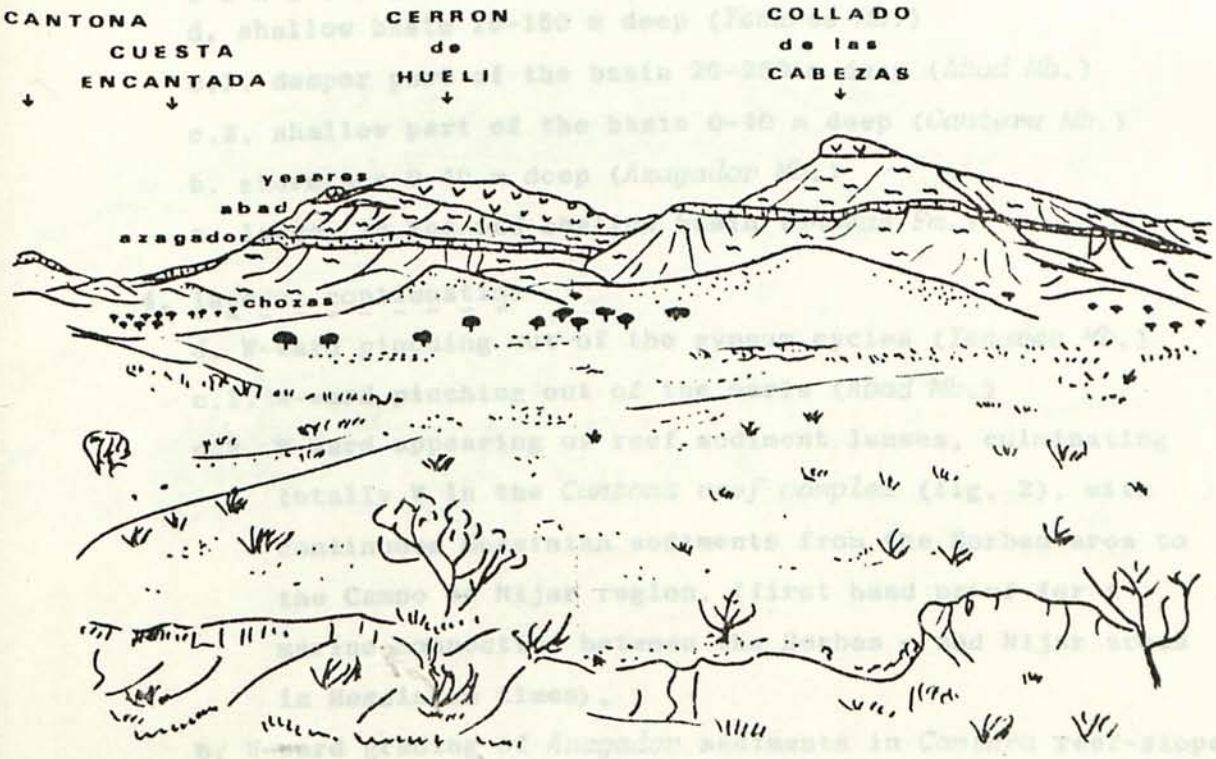
FIELDTRIP ITINERARY

INTRODUCTION TO THE SORBAS BASIN

STOPS: 1. Overall view of the base of the Messinian succession
2. Contact Messinian-basement rocks
3. Miocene fracture-zone
4. Tortonian turbidites
5. Contact Tortonian-Messinian
6. Contact Azagador Lst.Mb.-Abad marl Mb.
7. Contact Yesares gypsum Mb. (super-cones)-Sorbas Mb.
8. Contact Sorbas Mb. (sst)-Zorreras Mb.

STOP 1: OVERALL VIEW OF THE BASE OF THE MESSINIAN SUCCESSION.

Location: Peñas Negras (14 km from Sorbas on the road to Nijar)



STOP 1:

Salient features:

1. stratigraphical succession
   - d. Messinian Yesares gypsum Member (Caños Fm.)
   - c.1. Messinian Abad marl Member (Turre Fm.)
   - c.2. Messinian Cantera reef Member (Turre Fm.)
   - b. Messinian Azagador limestone Member (Turre Fm.)
   - a. Tortonian Chozas marl & sst. Fm.

2. lithological succession
   - d. thick basal selenite cycles (*Yesares Mb.* 0-130 m thick)
   - c.1. microfaunal rich marls (*Abad Mb.* 0-70 m thick)
   - c.2. reef lst. beds and lenses (*Cantera Mb.* 0-120 m thick)
   - b. macrofaunal rich calcarenites (*Azagador Mb.* 10-20 m thick)
   - a. marls, sst. congl. turbidites (*Chozas Fm.* 400-2000 m thick)

3. environmental succession
   - d. shallow basin 15-150 m deep (*Yesares Mb.*)
   - c.1. deeper part of the basin 20-250 m deep (*Abad Mb.*)
   - c.2. shallow part of the basin 0-40 m deep (*Cantera Mb.*)
   - b. shoreface 0-40 m deep (*Azagador Mb.*)
   - a. large, in the end shallow basin (*Chozas Fm.*)

4. lateral continuation
   - d. W-ward pinching out of the gypsum cycles (*Yesares Mb.*)
   - c.1. W-ward pinching out of the marls (*Abad Mb.*)
   - c.2. W-ward appearing of reef sediment lenses, culminating totally W in the *Cantona reef complex* (fig. 2), with continuous Messinian sediments from the Sorbas area to the Campo de Nijar region. (first hand proof for a marine connection between the Sorbas - and Nijar areas in Messinian times).
   - b. W-ward grading of *Azagador* sediments in *Cantera* reef-slope sediments.
   - a. SW-ward tectonical oversteepening of stratification NE-ward undisturbed horizontal stratification. (*Chozas Fm.*)

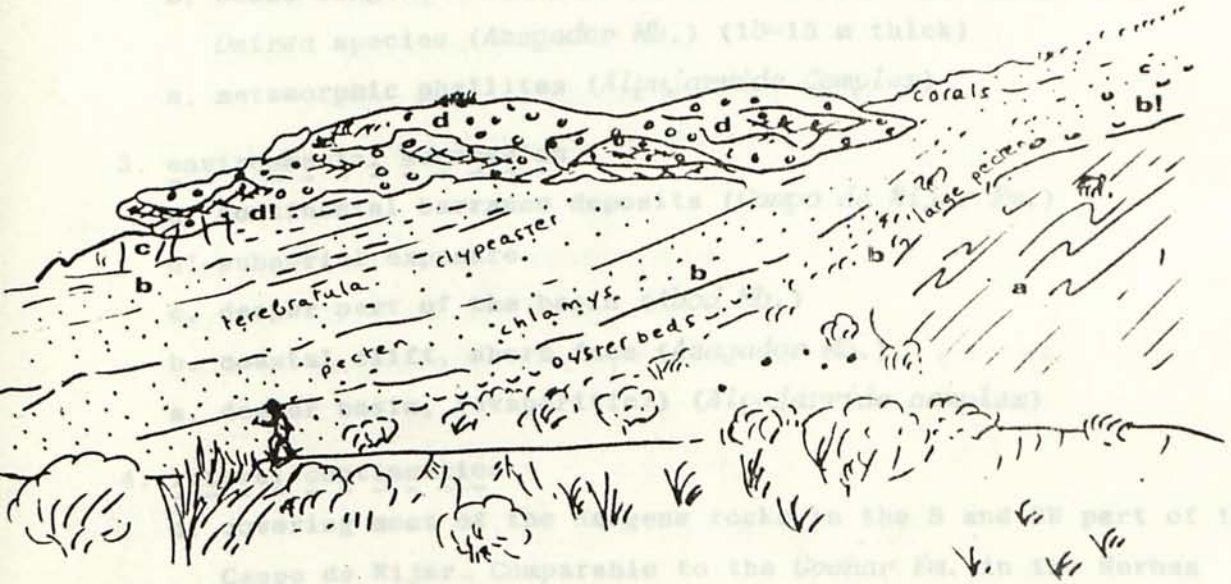
Contacts:

5. *Abad marl Mb.-Yesares gypsum Mb.*; disturbed by rockslides
4. *Abad marl Mb.-Cantera reef Mb.*; lateral transition
3. *Azagador lst. Mb.-Cantera reef Mb.*; vertical transition
2. *Azagador lst. Mb.-Abad marl Mb.*; vertical transition
1. *Tort. Chozas Fm.-Mess. Azagador Mb.*; angular unconformity

STOP 2:

CONTACT MESSINIAN - BASEMENT ROCKS

Location: Cerro de las Cuevas (18,5 km S from Sorbas on the road to Nijar).



STOP 2:

Salient features:

1. stratigraphical succession
   - d. Pliocene-Pleistocene "Campo de Nijar" congl. Fm.
   - c. Messinian Abad marl Member (Turre Fm.)
   - b. Messinian Azagador lst. Member (Turre Fm.)
   - a. Pre-Tertiary Alpujarride basement rocks

2. Lithological succession
   - d. alluvial fan conglomerates (*Campo de Nijar Fm.*). (few m thick)
   - d! caliche soil underneath conglomerates (few cm thick)
   - c. (partly) eroded, leached marls (*Abad Mb.*) (few m thick)
   - b. benthocalcarenite with brachiopods (e.g. *Terebratula*), molluscs (e.g. *Pecten, Ostrea, Chlamis*), algae, bryozoans, echinoids (e.g. *Clypeaster*).
   - b! basal conglomerate with bored pebbles, large *Pecten* and *Ostrea* species (*Azagador Mb.*) (10-15 m thick)
   - a. metamorphic phyllites (*Alpujarride Complex*)

3. environmental succession
   - d. continental barranco deposits (*Campo de Nijar Fm.*)
   - d! subaerial exposure
   - c. deeper part of the basin (*Abad Mb.*)
   - b. coastal cliff, shore face (*Azagador Mb.*)
   - a. deeper basin, (evaporitic?) (*Alpujarride complex*)

4. lateral continuation
   - d. covering most of the Neogene rocks in the S and SW part of the Campo de Nijar. Comparable to the *Gochar Fm.* in the Sorbas depression.
   - c. W-ward pinching out of the *Abad* marls, transition into the reef limestones of the *Cantera reef Mb.*
   - b. N-ward comparable to the *Azagador* of the Sorbas and Vera basins. E.ward disruption close to the Mediterranean coast of volcanic rocks.

W-ward continuous up to Nijar, present all along the S margins of the Sierra de Gádor and the Sierra Alhamilla.

a. present in all of the S. Sierras.

Contacts:

3. *Abad Mb.-Campo de Nijar Fm.*; angular unconformity
2. *Azagador Mb.-Abad Mb.* ; transitional
1. *Basement-Azagador Mb.* ; angular unconformity, faulted

Salient features: E of the road.

1. Stratigraphic succession:
   d. Messinian gypsum (Yesares Mb.)
   c. Messinian marls (Abad Mb.)
   b. Messinian benthocalcarenites (Azagador Mb.)
   a. Pre-Tertiary basement rocks (Alpujarride complex)

2. Lithological succession:
   d. 60 m of selenitic gypsum (at least 10 cycles) with a locally alabastrine base (*Yesares Mb.*)
   c. 1 m of microfaunal rich marls (*Abad Mb.*)
   b. and a. as on the W side of the road.

Contacts:

3. *Abad Mb.-Yesares Mb.*; conformable
2. *Azagador Mb.-Abad Mb.*; transitional
1. *Basement-Azagador Mb.*; angular unconformity or faulted.

STOP 3:

MIOCENE FRACTURE ZONE

Location: Peñas Negras (15,8 km S from Sorbas on the road to Nijar)

Salient features:

1. mylonitized lithologies of Alpujarride and Malaguide basement complexes and Neogene basin sediments.
2. uplift Sierra Cabrera caused by Germano-type tectonics.

STOP 4:

TORTONIAN TURBIDITES

Location: 13 km S from Sorbas on the road to Nijar.

Salient features:

1. The turbidites are part of the Tortonian Chozas Fm. and show a variety of solemarks, burrows and sand volcanos.
2. Current directions indicate a western origin of the sediment.

STOP 5:

CONTACT TORTONIAN-MESSINIAN

Location: 10,6 km S from Sorbas on the road to Nijar.

Salient features:

1. stratigraphical succession:

   b. Messinian Azagador lst. Mb. (Turre Fm.)

   a. Tortonian Chozas Formation

2. lithological succession:

   b. macrofaunal rich calcarenites (*Azagador Mb.*) 15 m thick

   a. silty marls and sandstones (*Chozas Fm.*)

3. environmental succession:

   b. shoreface 0-40 m deep (*Azagador Mb.*)

   a. shallow basin (*Chozas Fm.*)

Contacts:

1. *Tort.Chozas Fm.-Mess.Azagador Mb.*; angular unconformity.

STOP 6:

CONTACT AZAGADOR LST. MB. AND ABAD MARL MB.

Location: El Rio de Aguas valley, 8,8 km S from Sorbas on the road to Nijar.

Salient features:

1. stratigraphical succession:

   b. Messinian Abad marl Member (Turre Formation)

   a. Messinian Azagador lst. Member (Turre Formation)

2. lithological succession:

   b. greyish microfaunal rich marls (*Abad Mb.* 120 m thick)

   a. macrofaunal rich calcarenites (*Azagador Mb.* 15 m thick)

3. environmental succession:

   b. deeper part of the basin 20-250 m deep (*Abad Mb.*)

   a. shoreface 0-40 m deep (*Azagador Mb.*)

4. lateral continuation:

   b. the Abad marls increase in thickness from 0 m in the W (Cuesta Encantada (stop 1)), to 200 m at Las Perales a village 2 km NE of stop 6.

   a. the Azagador lst. increase in thickness from 10 m in the Cuesta Encantada (stop 1) to 90 m in the NE part of the basin, 8 km NE of stop 6.

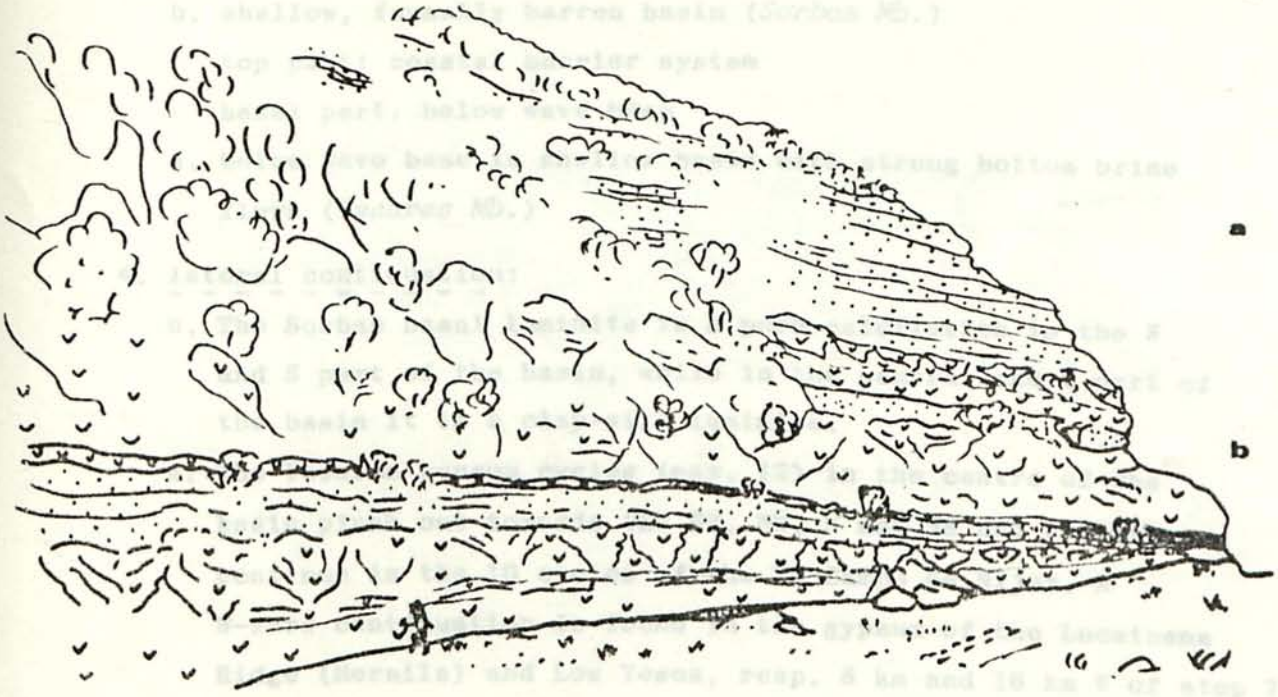
Contacts:

1. *Azagador Mb.-Abad Mb.*; transitional

STOP 7:

CONTACT YESARES GYPSUM MB. (SUPER-CONES)-SORBAS MB.

Location: Rio de Aguas, 500 m W of the bridge over the Rio de Aguas on the road from Sorbas to Nijar.



Salient features:

1. stratigraphical succession:
   b. Messinian Sorbas Member (Caños Formation)
   a. Messinian Yesares Member (Caños Formation)

2. lithological succession:
   b. top: calcareous sst. with megasets
   base: carbonate and clay laminite with parallel lamination and low angle truncation
   (*Sorbas Mb.* max. 65 m thick)

a. large cycles of selenitic gypsum beds and alternating dolomite calcite clay laminae with low angle trunctions. Example of primary gypsum growth in cones, super-cones and massive selenite beds, incorporating clastic sedimentary structures.

3. environmental succession

b. shallow, faunally barren basin (*Sorbas Mb.*)
top part: coastal barrier system
basal part: below wave base

a. below wave base in shallow basin with strong bottom brine flows (*Yesares Mb.*)

4. lateral continuation:

b. The Sorbas basal laminite is a pure calcilutite in the N and S part of the basin, while in the central and E part of the basin it is a clay-silt laminite.

a. The Yesares gypsum cycles (max. 12) in the centre of the basin pinch out towards the SW, NW, N and NE and probably continue in the 10 cycles of the NE Campo de Nijar. A W-ward continuation is found in the gypsum of the Lucainena Ridge (Moraila) and Los Yesos, resp. 8 km and 16 km W of stop 7.

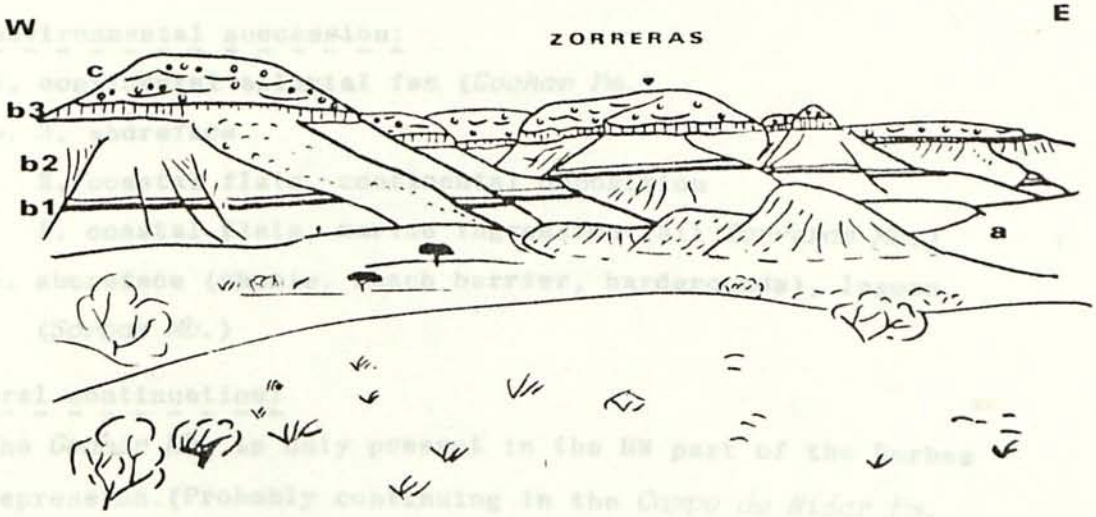
Contacts:

1. *Yesares Mb.-Sorbas Mb.*; transitional

STOP 8:

CONTACT SORBAS MB. AND ZORRERAS MB.

Location: 2 km E from Sorbas on the road to Lubrín.



(modified after Roep. This stop coincides with Stop no. 8 of the Sorbas-Zorreras excursion of Roep & Beets.)

Salient features:

1. stratigraphical succession:
   - c. Plio-Pleistocene Gochar Formation
   - b. "partly" Pliocene Zorreras Mb. (Caños Fm.)
   - a. Messinian Sorbas Mb. (Caños Fm.)

2. lithological succession:

c. red conglomerates and sst. (*Gochar Fm.*)

b. 3. yellow marine fossiliferous calcareous sst.

2. red burrowed sands and clays

1. white calcilutites and clay layers (all *Zorreras Mb.*)

a. calcareous sst. with megaripples, beachrock congl. burrows and laminated clayey intervals (*Sorbas Mb.*)

3. environmental succession:

c. continental alluvial fan (*Gochar Fm.*)

b. 3. shoreface

2. coastal flats, continental deposition

1. coastal flats, marine ingression (all *Zorreras Mb.*)

a. shoreface (shoals, beach barrier, hardgrounds), lagoon (*Sorbas Mb.*)

4. lateral continuation:

c. the *Gochar Mb.* is only present in the NW part of the Sorbas depression. (Probably continuing in the *Campo de Nijar Fm.* and the *Salmeron Fm.* (Vera).

b. the *Zorreras Mb.* is strongly thinning towards the N and W. Comparable sediments are found in the NE Campo de Nijar. No comparable sediments are found in the Vera basin.

a. Towards the W the *Sorbas Mb.* gets more calcareous, pinching out N-wards after 15 km. SW-wards the Sorbas sediments pinch out towards the *Cantera reef complex*. SE-ward there is a continuation in the calcilutites and calcarenites of the NE Campo de Nijar.

Contacts:

2. *Zorreras Mb.-Gochar Fm.*; (laterally angular) unconformable

1. *Sorbas Mb.-Zorreras Mb.*; transitional