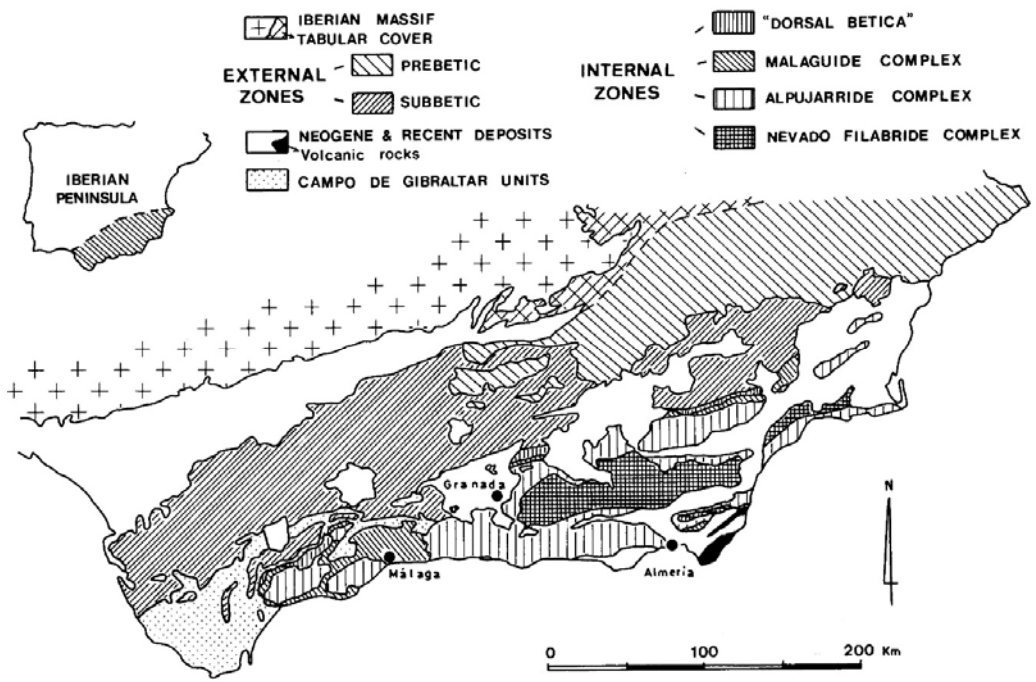
ALPUJÁRRIDE CARBONATES (S. SPAIN)

FIRST ATLANTIC MARINE DEPOSITS?

José M. Martín & Juan Carlos Braga

Key paper: Martin, J.M. and Braga, J. C. (1987). Alpujárride carbonate deposits (southern Spain). Marine sedimentation in a Triassic Atlantic. Palaeogeography, Palaeoclimatology, Palaeoecology, 59: 243-260.

OUTCROP DISTRIBUTION



GEOLOGICAL STRUCTURE

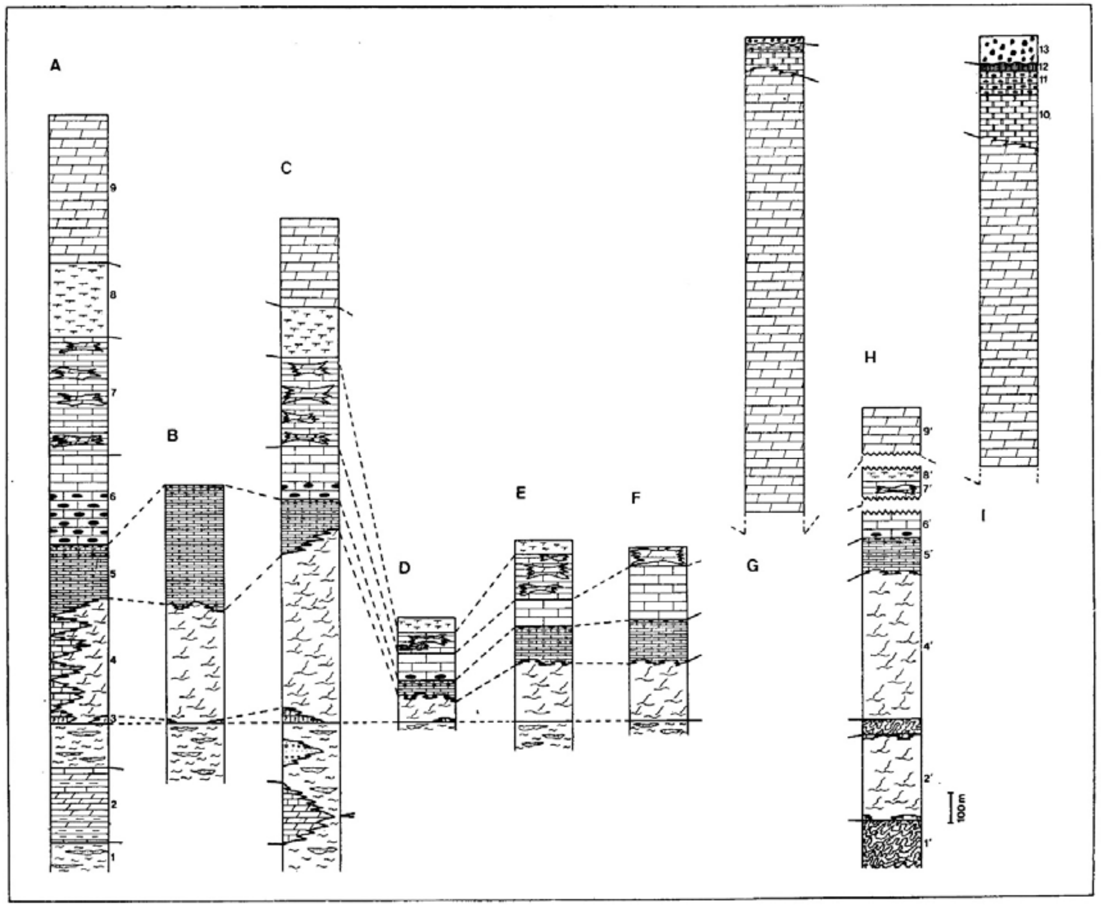
The Alpujárride Complex consists of a series of overthrusted nappes on top of the Nevado-Filábride Complex

Inverted sequences and recumbent folds are common features in the carbonates

MAIN ALPUJÁRRIDE SEQUENCES

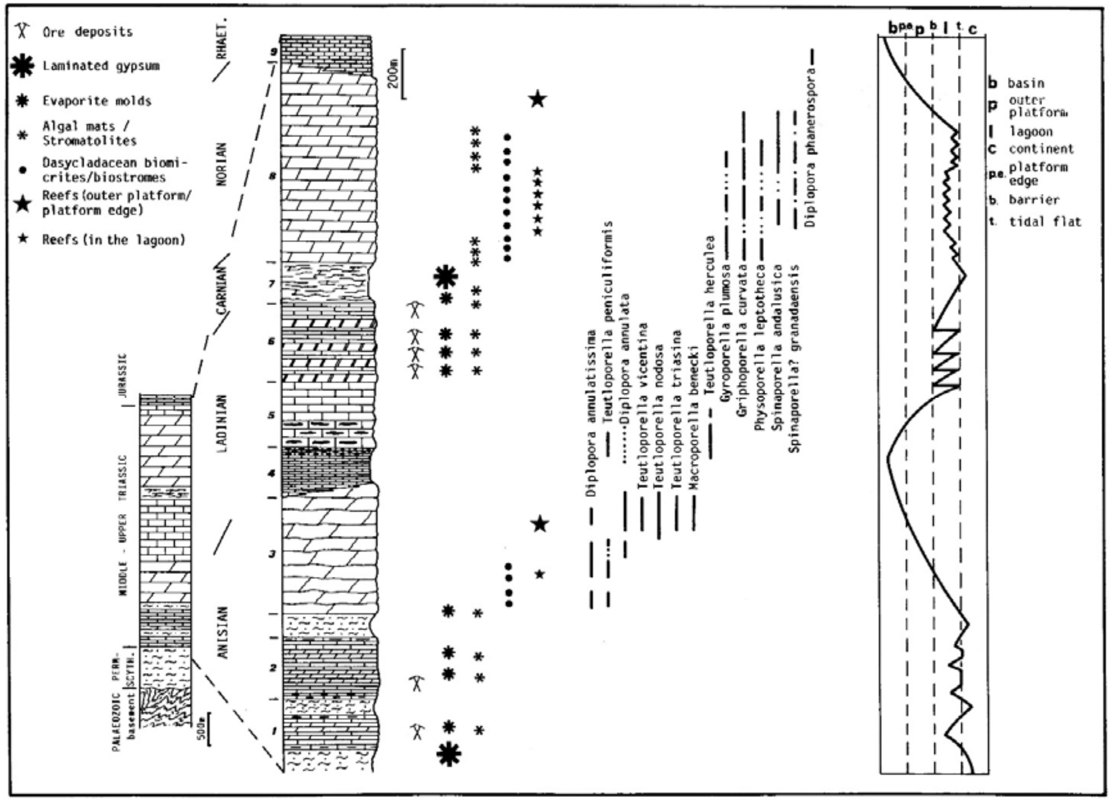
A: Santa Bárbara unit (Sierra de Baza). B: Quintana unit (Sierra de Baza). C. Lújar unit. D: San Jerónimo unit (Sierra Nevada). E: Víboras unit (Sierra Nevada). F: Cerrajón unit (Sierra Nevada). G: Trevenque unit (Sierra Nevada). H: Tejeda unit. I: Nieves unit.

1: Phyllites and quartzites. 2: Limestones, dolomites and calc-schists. 3: "Fucoides" limestones. 4: Lower "massive" dolomites. 5: Thinly-bedded limestones. 6: Cherty limestones. 7: Limestones and stratiform dolomites. 8: Clays, marls and marly limestones and dolomites. 9: Upper "massive" dolomites. 10: Marly limestones. 11: Thinly-bedded, cherty limestones. 12: Marly limestones, radiolarites and nodular limestones. At the Tejeda Unit equivalent rocks exhibit a high-degree of metamorphism.



SYNTHETIC ALPUJÁRRIDE SEQUENCE

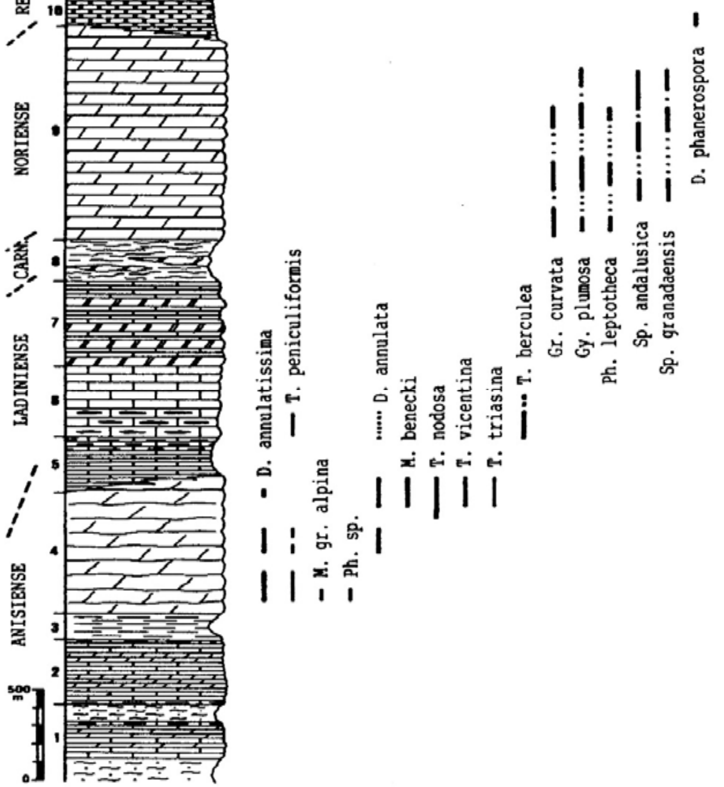
1-2: Carbonate intercalations within phyllites and quartzites; 3: Lower “massive” dolomites. 4: Finelly-stratified limestone and marly limestones. 5: Limestones (chert nodules at the base). 6: Limestones and stratiform dolomites. 7: Clays, marls, marly limestones and dolomites. 8: Upper “massive” dolomites. 9: Marly limestones.

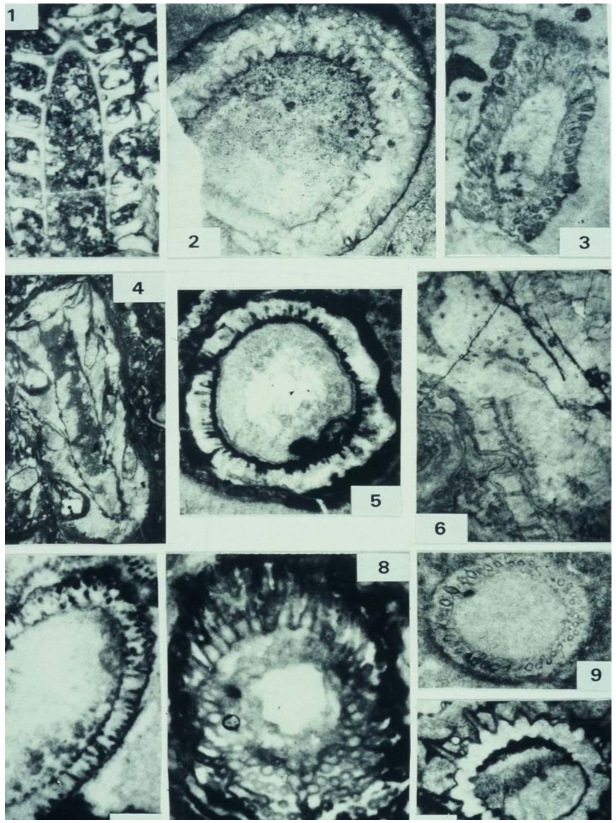


BIOSTRATIGRAPHY

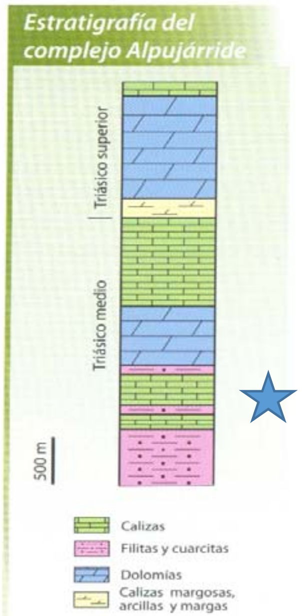
DASYCLADEACEAN ALGAL DISTRIBUTION

1: Diplopora annulatissima. 2: Teutloporella vicentina. 3: Macroporella benecki. 4: Teutloporella nodosa. 5. Spinoporella andalusica. 6: Diplopora annulata. 7. Griphoporella curvata. 8: Spinaporella granadaensis. 9: Gyroporella plumosa. 10. Spinoporella andalusica.





CARBONATE INTERCALATIONS WITHIN PHYLLITES AND QUARTZITES
Representative facies



Planar and domical stromatolites

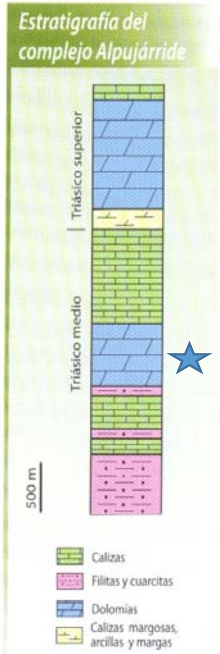
"Algal mats" with birds-eyes

Evaporite molds

Laminated gypsum

Carstic cavity with dolomitized internal infilling

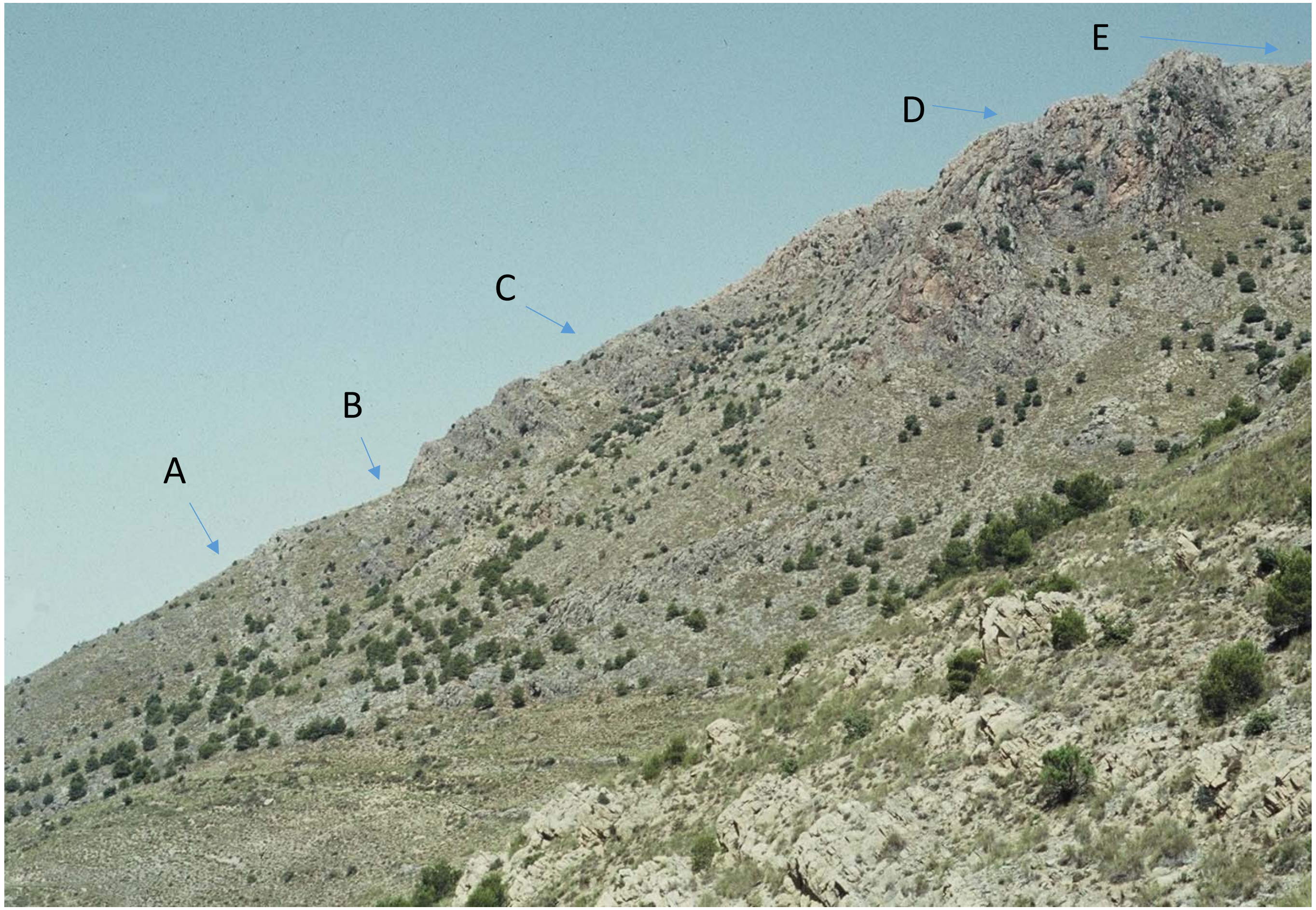
LOWER “MASSIVE” DOLOMITES



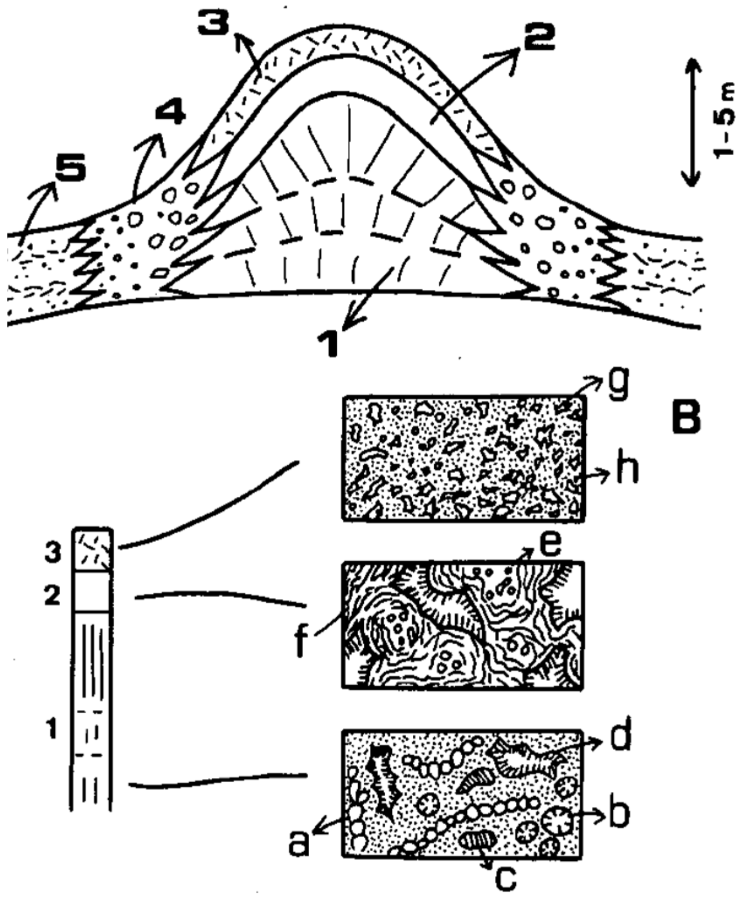
LAS JUNTAS SECTION

Sierra de Baza

A: “Algal mats”. B: Biomicrites. C: Bioclastic calcarenites. D: Reefs. E: Calcareous breccias



ANISIAN REEFS: INTERNAL STRUCTURE



1 Mound core: bafflestone of sphinctozoans, corals and solenoporacean algae

2 Lower cap: serpulid-stromatolite-cement boundstone

3 Upper cap: thrombolite boundstone

4 Flank breccias

5 Bioclastic calcarenites

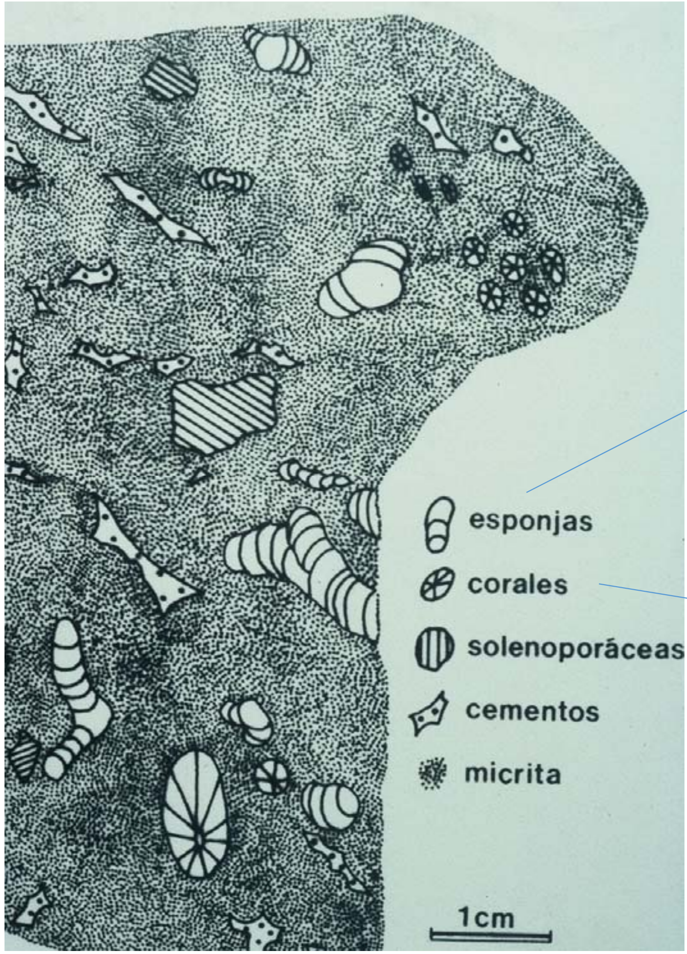
a) Sphintozoans; b) Corals; c) Solenoporacean algae; d) Synsedimentary cements

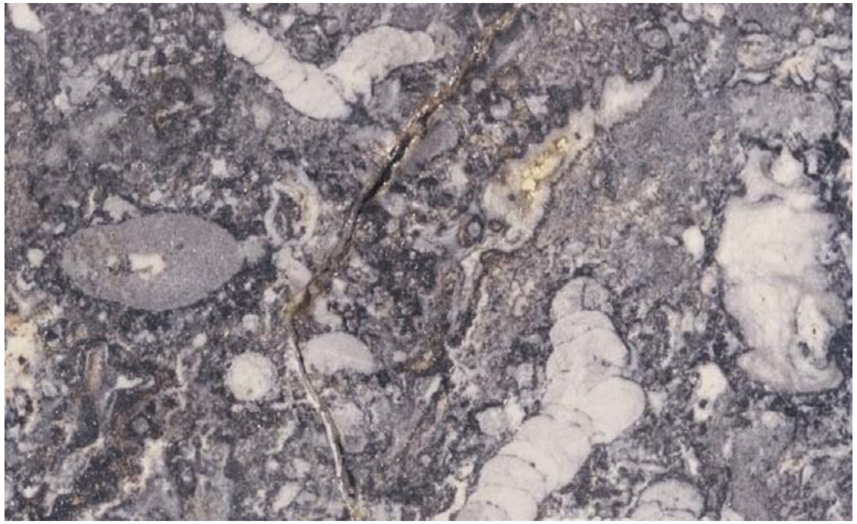
e) Serpulids; f) Stromatolites

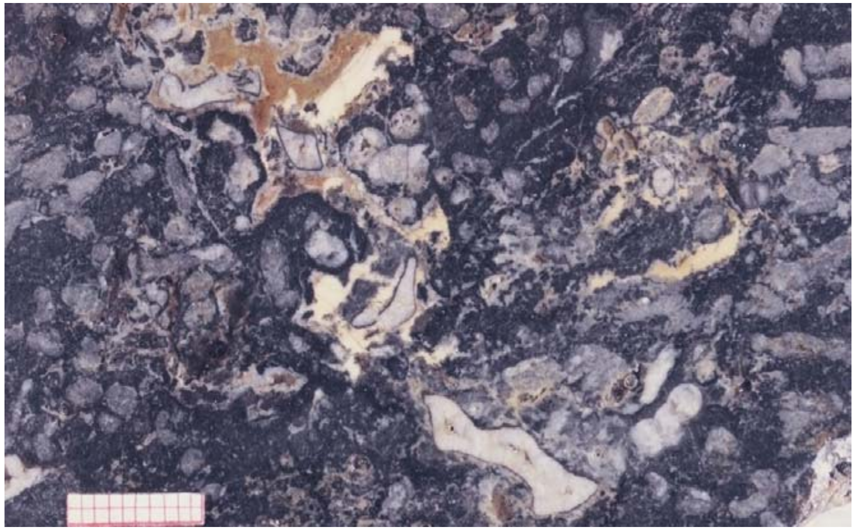
g) Microbial micrite; h) Fenestral voids

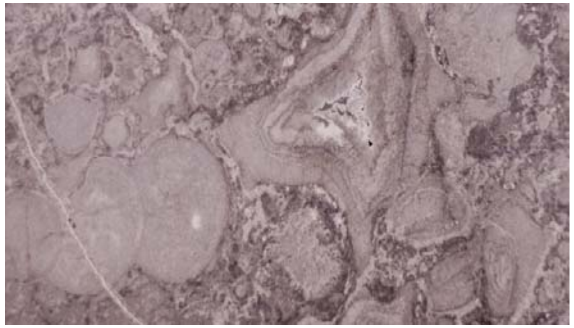
ANISIAN MOUNDS: CORE FACIES

BAFFLESTONE OF SPHINTOZOANS, CORALS AND SOLENOPORACEAN ALGAE

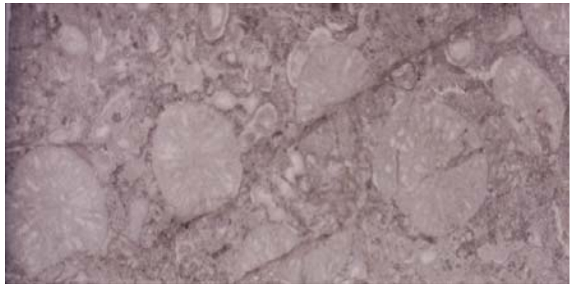






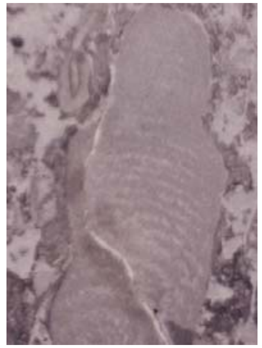


Sphintozoans



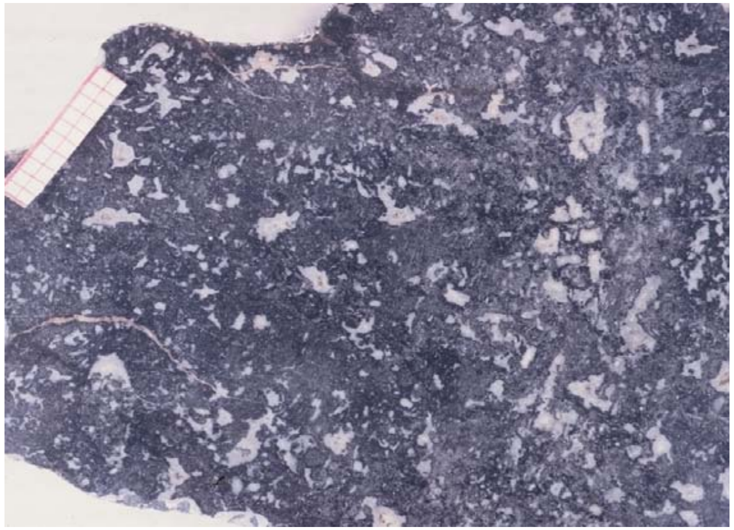
Corals

Microscopic views



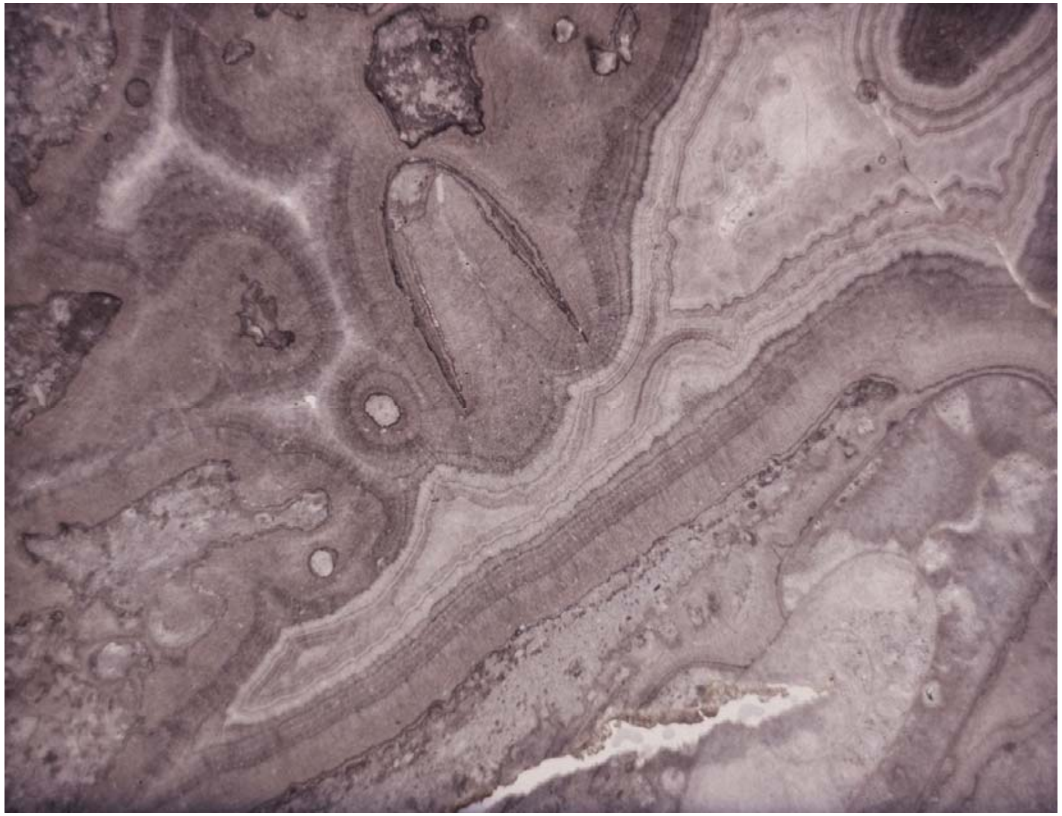
Solenoporacean algae

ANISIAN MOUNDS: CAP FACIES

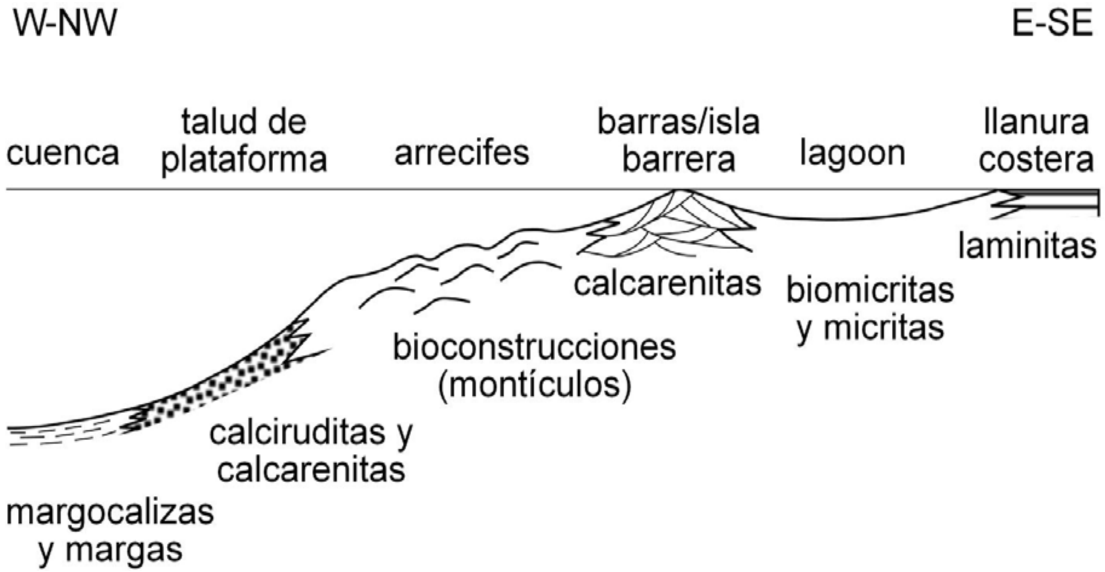


DOUBLE CAP
A lower serpulid-stromatolite-cement boundstone and an upper thrombolite boundstone

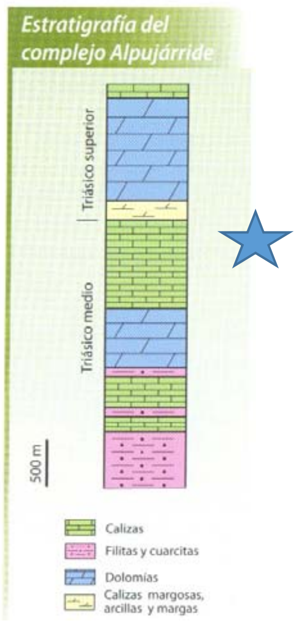
ANISIAN MOUNDS: THE REEF-TALUS BRECCIAS

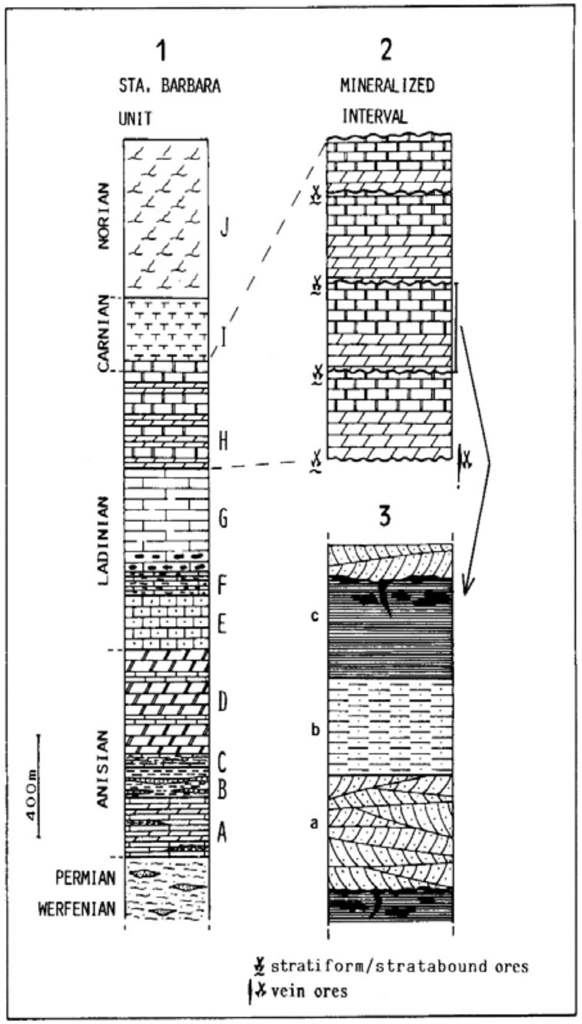


ANISIAN SEDIMENTARY MODEL



THE UPPERMOST LADINIAN-LOWERMOST CARNIAN CARBONATES



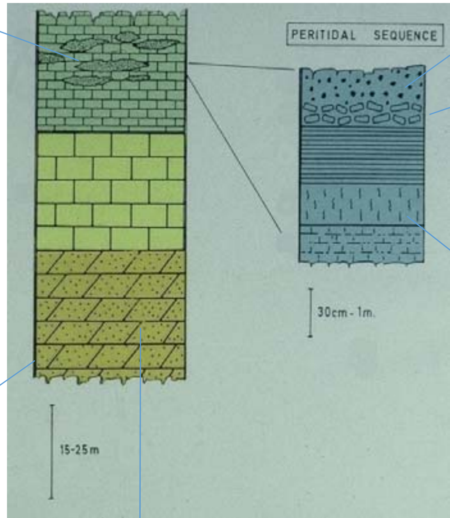


It consists of four megasequences with dolomites at the bottom and limestones on top, separated by carstified erosional surfaces.

Each megasequence comprises from bottom to top (a) dolomitized cross-bedded calcarenites (shoal-deposit), (b) micrites (lagoonal deposit) and (c) “algal-mats” (peritidal deposit). Carstic cavities occurs also on top.

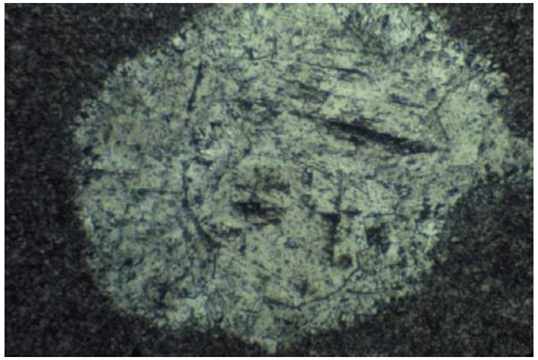
THE UPPERMOST LADINIAN-LOWERMOST CARNIAN CARBONATES

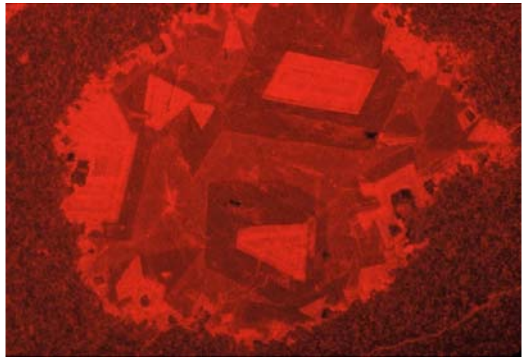
REPRESENTATIVE FACIES



Carstic cavities with dolomitized infilling

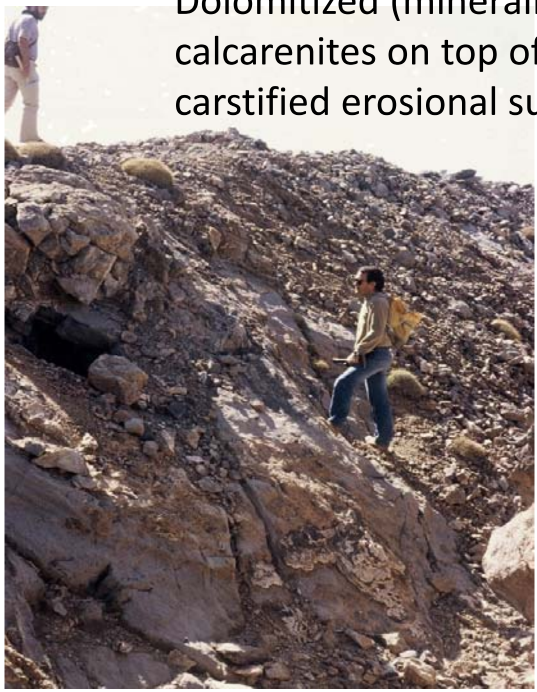
Anhidrite nodules replaced by dolomite



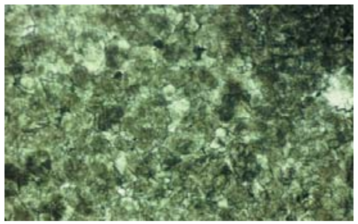


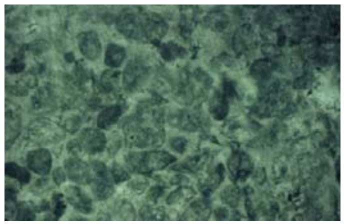
Intraclastic breccias interbedded with algal mats

Dolomitized (mineralized) calcarenites on top of carstified erosional surface



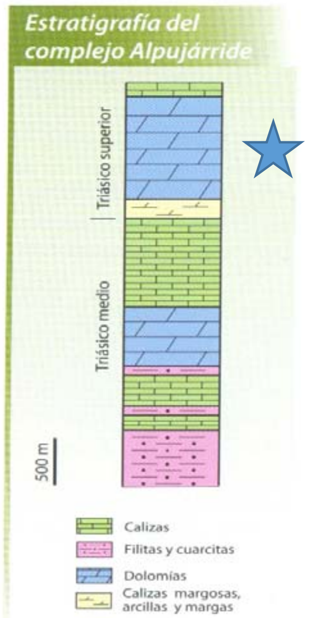
Bioturbated micrites





Dolomitized calcarenites

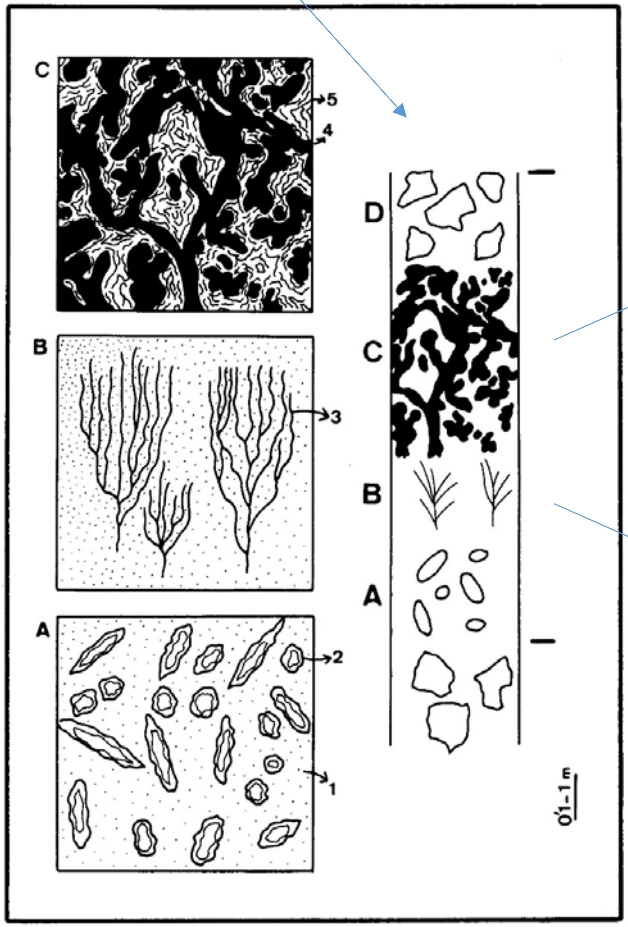
THE UPPER “MASSIVE” DOLOMITES



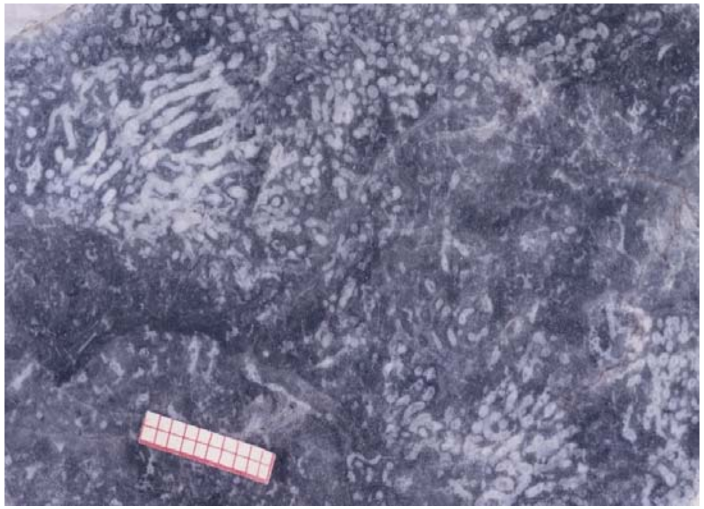
The upper dolomite is up to 1000 m thick. Three distinct parts are distinguished. The lower part consits of repetitive, platform cyclothems. In the middle part restricted coastal and lagoonal facies are ubiquiteous. In the upper part reefs are dominant.

THE UPPER "MASSIVE" DOLOMITES: THE PLATFORM CYCLOTHEMS

A: Dasycladacean floatstone.
B: Solenoporacean bafflestone.
C: Serpulid-Tubiphytes-cement boundstone.
D: Breccias.



1: Micrite. 2: Dasycladacean algae. 3: Solenoporacean algae. 4: Tubiphytes. 5: Synsedimentary marine cements.

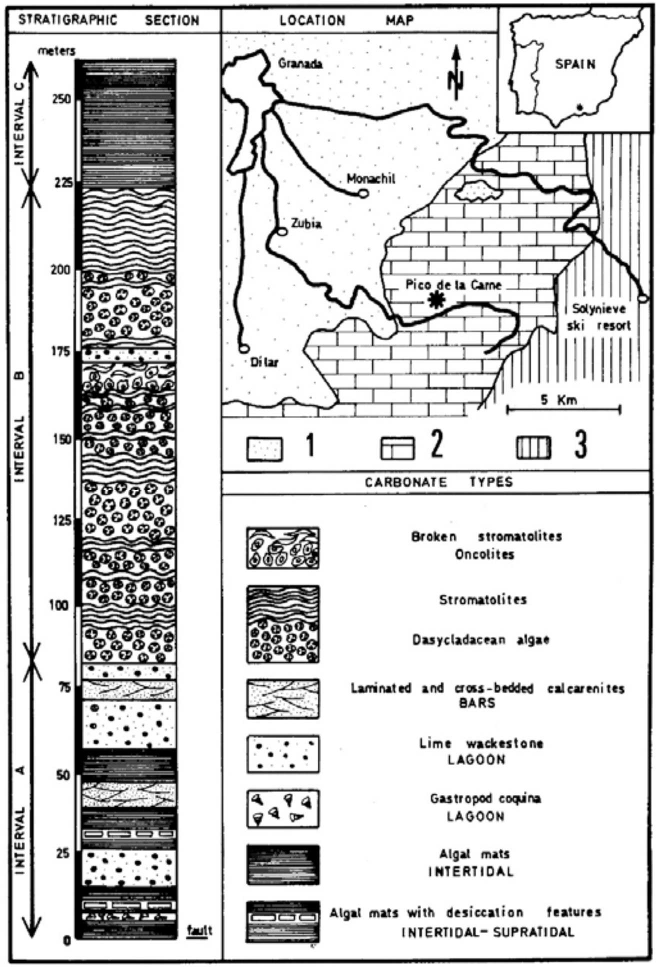


Interpretation

These cyclothems consist of deepening-upwards sequences topped by carbonate breccias, the latter resulting from tectonically-induced, cyclical subaerial exposition and subsequent erosion.

The sedimentary environment was that of an open, gentle-dipping ramp.

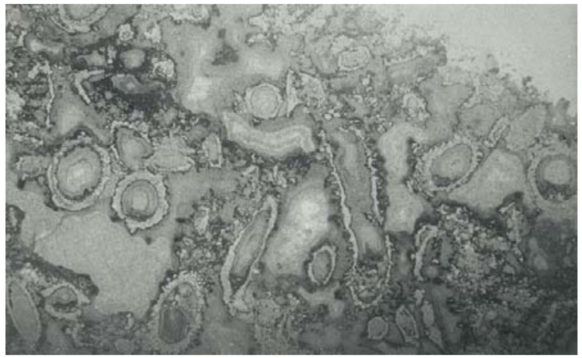
THE UPPER, “MASSIVE” DOLOMITES: THE MARGINAL, RESTRICTED FACIES



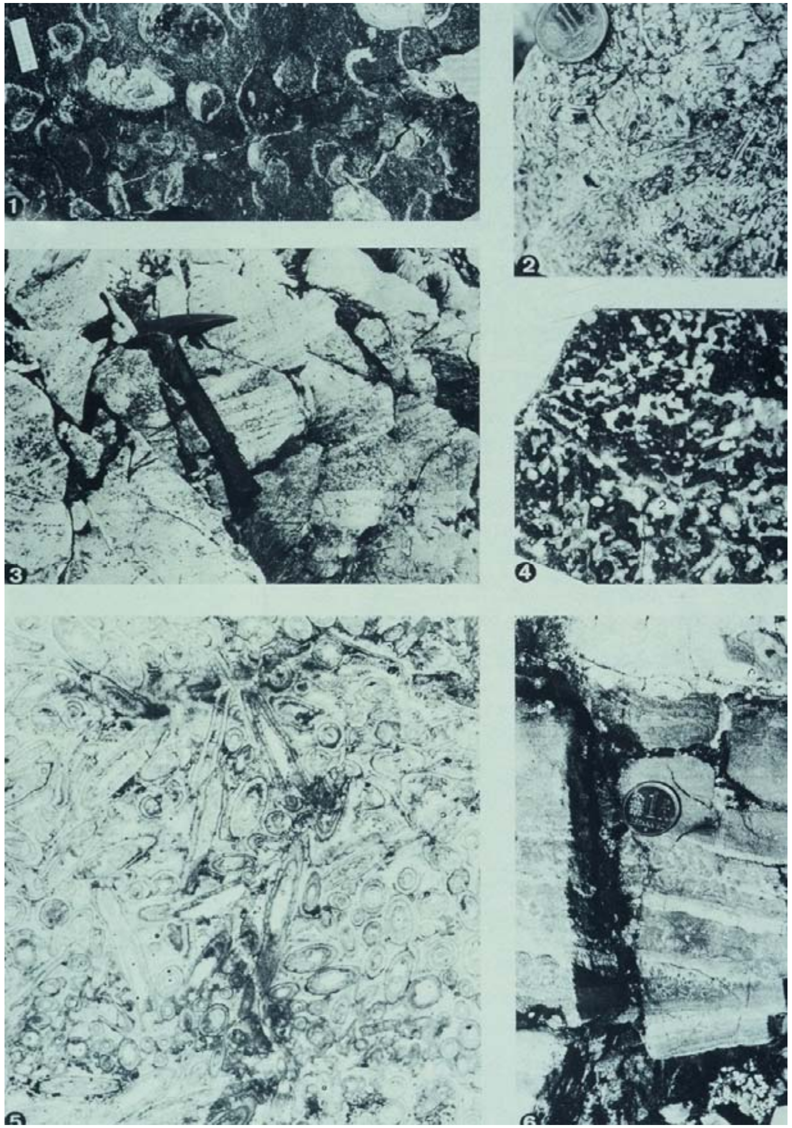
At the Pico de la Carne section , marginal, restricted facies consisting of Dasycladacean biostrome-stromatolite interbeddings are nicely exposed

Dasycladacean-stromatolite alternation

The microbial carbonates are locally thrombolitic



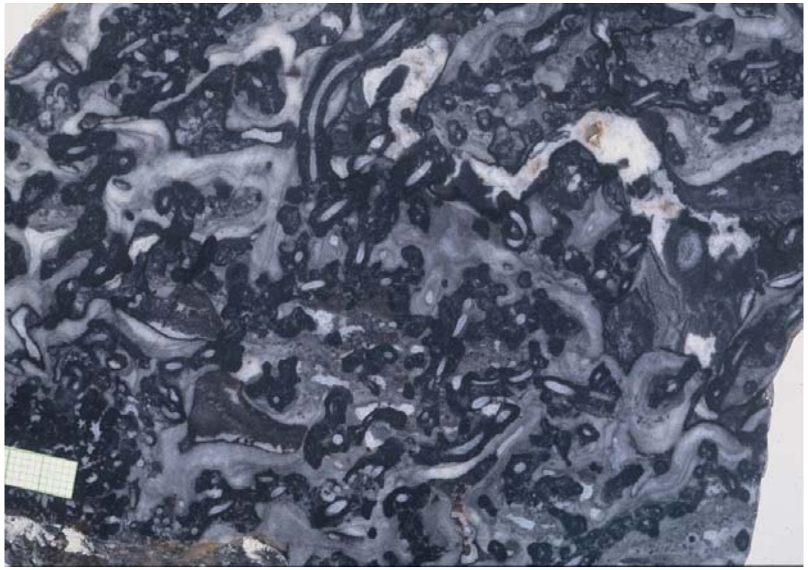
In the Dasycladacean biostromes the Dasycladacean thalli are oriented perpendicular to bedding and interconnected by submarine cements

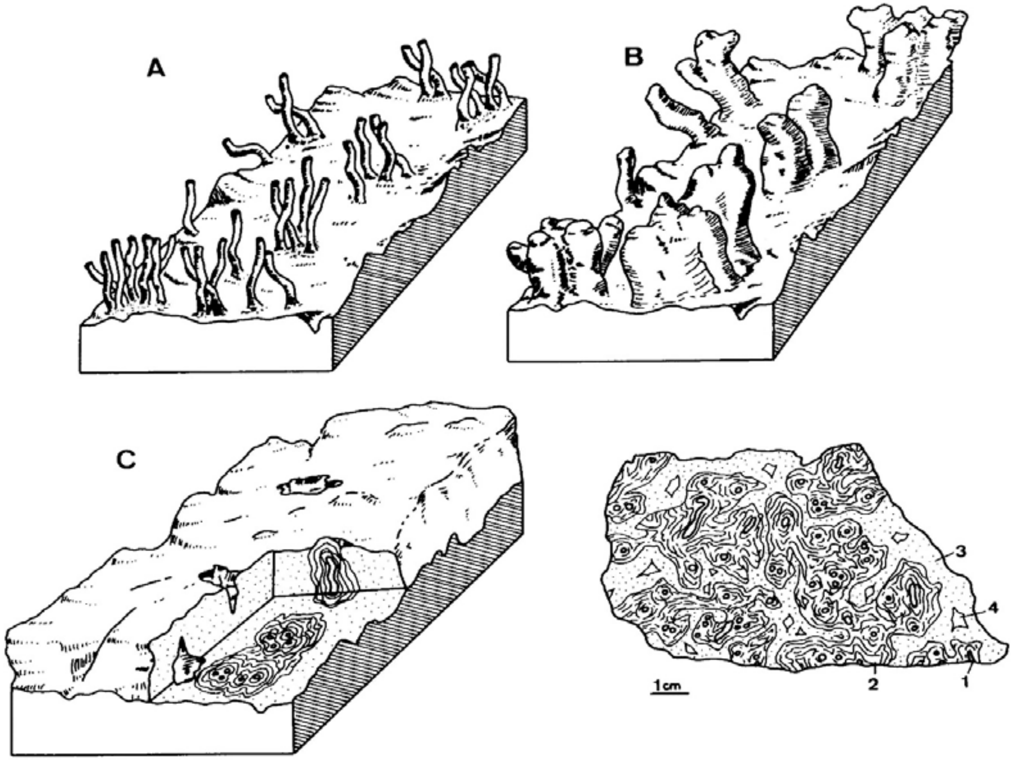


THE UPPER, "MASSIVE" DOLOMITES:
THE SHOAL FACIES

Major shoal facies:
1: Dolomitized bioclastic calcarenites with Megalodons.
2: Dolomitized Dasycladacean calcirudites with densely-packed, well-preserved algal thalli.
3: Cross-bedded, dolomitized Dasycladacean calcirudites.
4: Bioclastic micrite with synsedimentary voids filled by cements.
5: Dolomitized Dasycladacean grainstone.
6: Laminated oncolitic and micritic interbeddings.

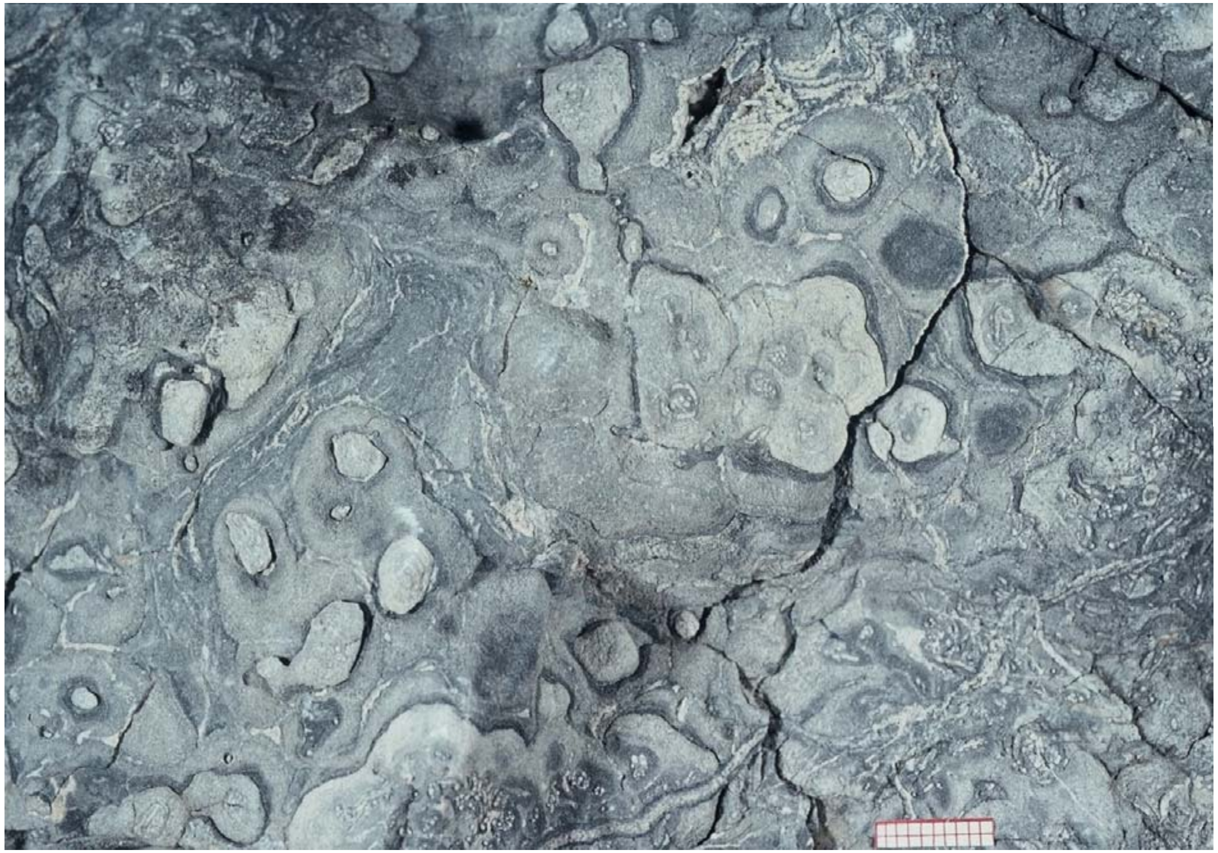
THE UPPER “MASSIVE” DOLOMITES: THE REEFS (I)

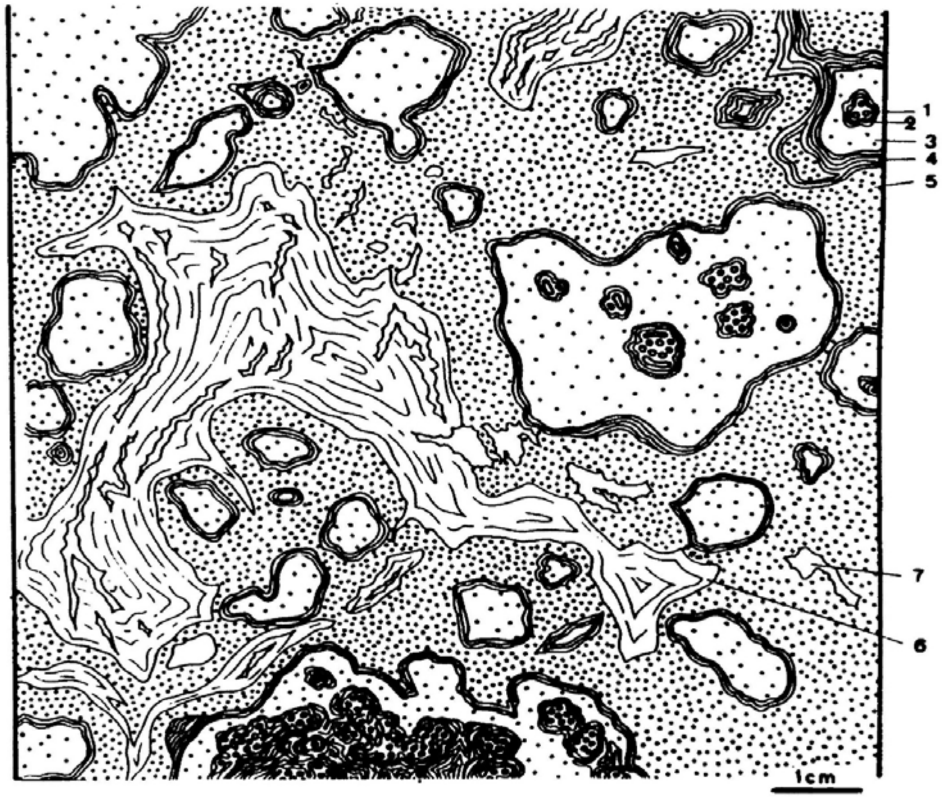




Serpulid-Tubiphytes/stromatolite-cement bioconstructions: Genetic model. A: Colonization of the substrate by serpulid worms (1). B. Encrustation by Tubiphytes and stromatolites (2). C: Filling of the remaining voids by synsedimentary aragonitic cement and/or early-lithified internal bioclastic sediment (3). Open voids are filled later by sparry calcite.

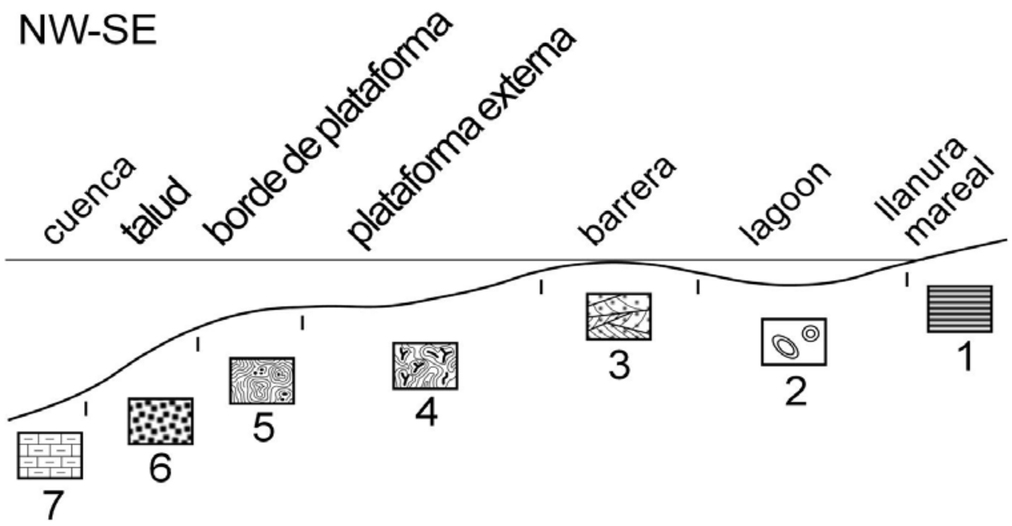
THE UPPER "MASSIVE" DOLOMITES: THE REEFS (II)





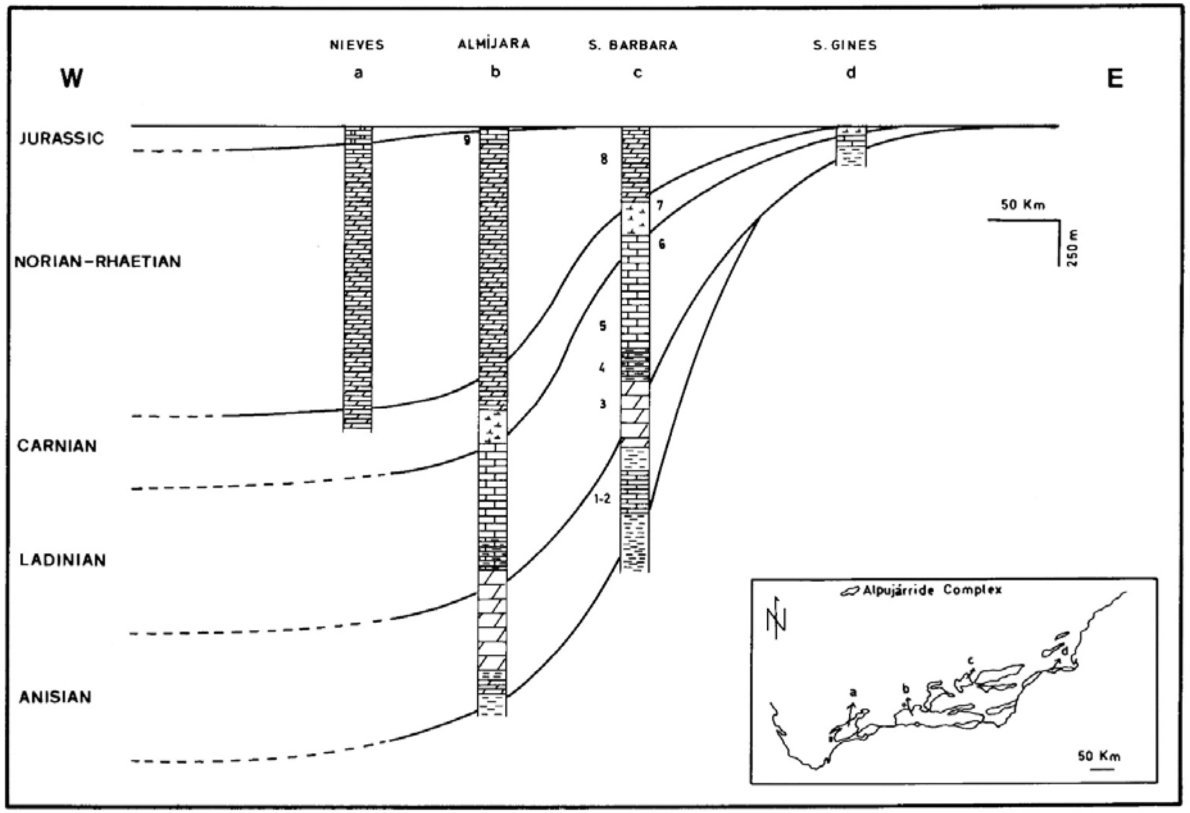
In the more complex bioconstructions several generations of stromatolites, Tubiphytes and synsedimentary-cement crusts occur around serpulid aggregates. 1: Serpulids. 2-3: Encrusting Tubiphytes. 4: Encrusting stromatolites. 5: Synsedimentary-cement layers. 6: Encrusting stromatolites. 7: Remaining voids filled by sparry calcite.

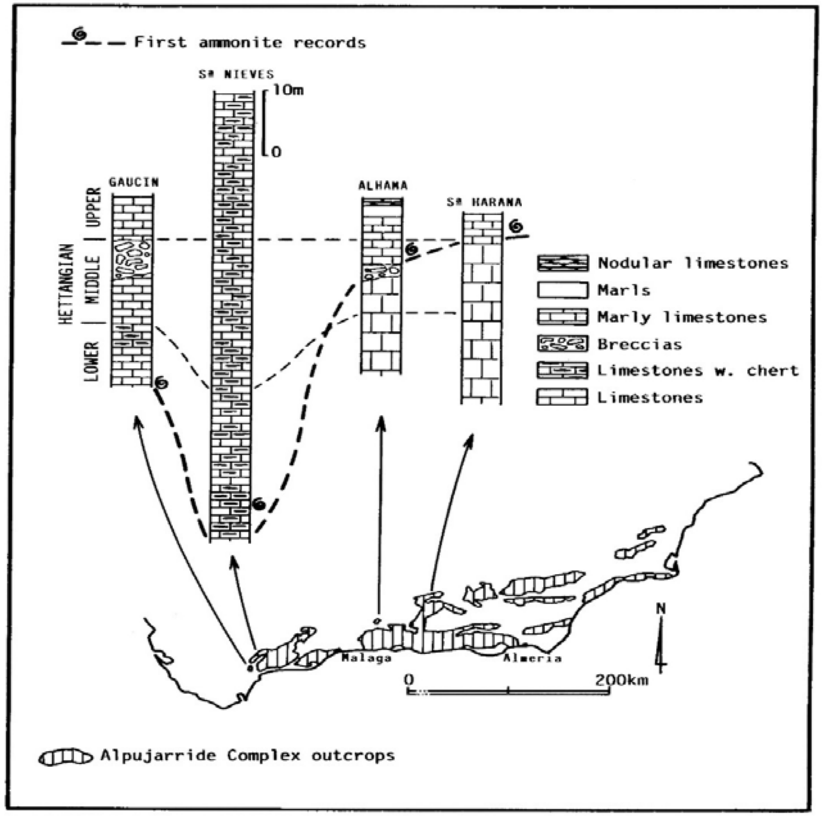
NORIAN SEDIMENTARY MODEL



1: "Algal mats"/stromatolites. 2: Dasycladacean floatstones/boundstones. 3: Calcarenites/calcirudites with abundant Dasycladacean remains. 4: Simple serpulid-Tubiphytes/stromatolite-cement bioconstructions. 5: Complex serpulid-Tubiphytes/stromatolite-cement bioconstructions. 6: Bioclastic calcarenites/calcirudites. 7: Marly limestones.

AN ATTEMPT TO RECONSTRUCT THE ALPUJÁRRIDE BASIN
STRATIGRAPHIC EVIDENCES

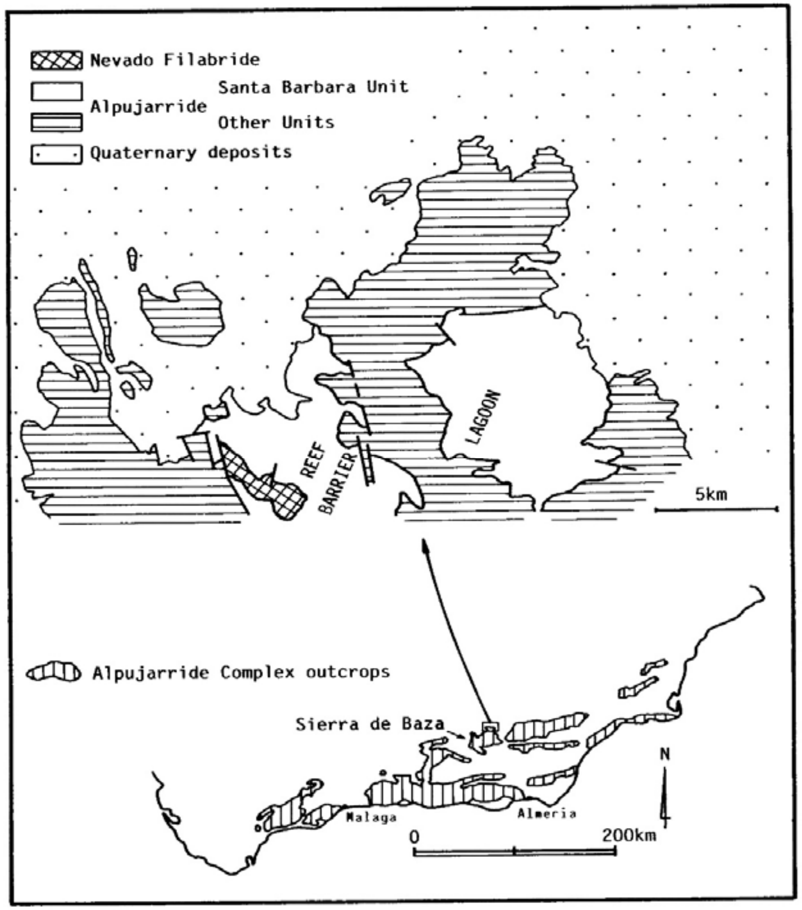




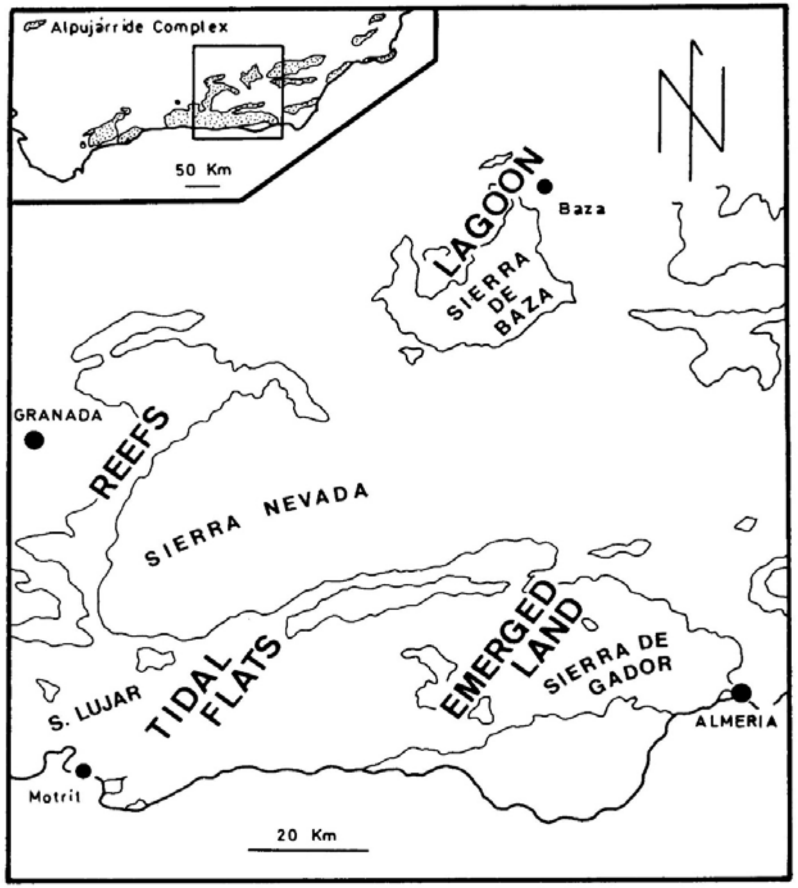
Stratigraphic units thicken towards the west and thin out and dissappear towards the east. The further east the more recent the carbonate sedimentation become.

In the Lowermost Liassic the earliest facies containning ammonites occurs to the west.

SEDIMENTOLOGICAL EVIDENCES: FACIES BELT DISTRIBUTIONS



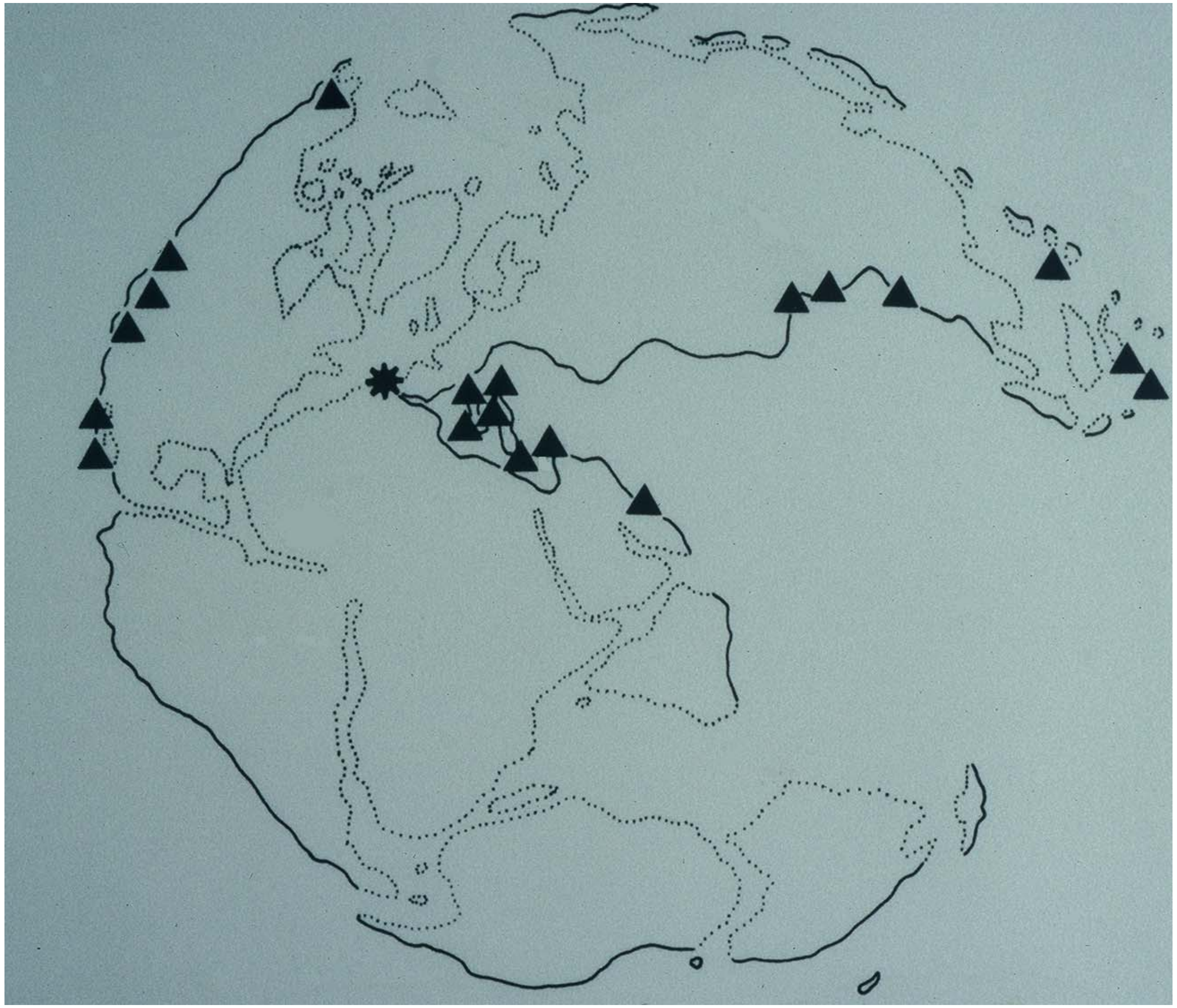
Anisian



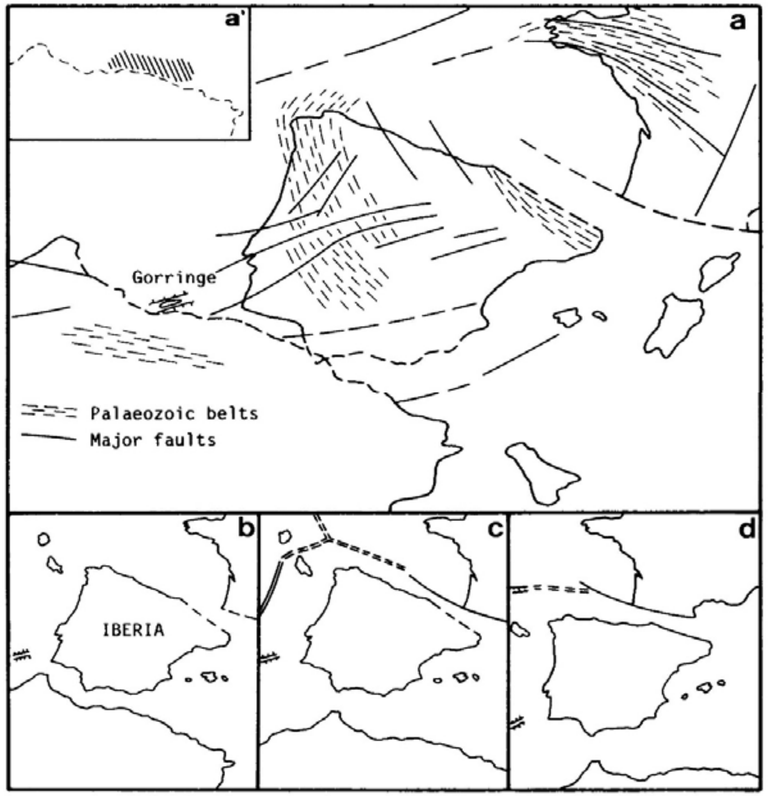
Norian

Facies belts are trending SW-NE, with the open-sea to the west.

ORIGINAL POSITION OF THE ALPUJÁRRIDE BASIN



Global Triassic paleogeography. Asteric marks the inferred position of the Alpujárride basin. Triangles are major Triassic-reef localities.

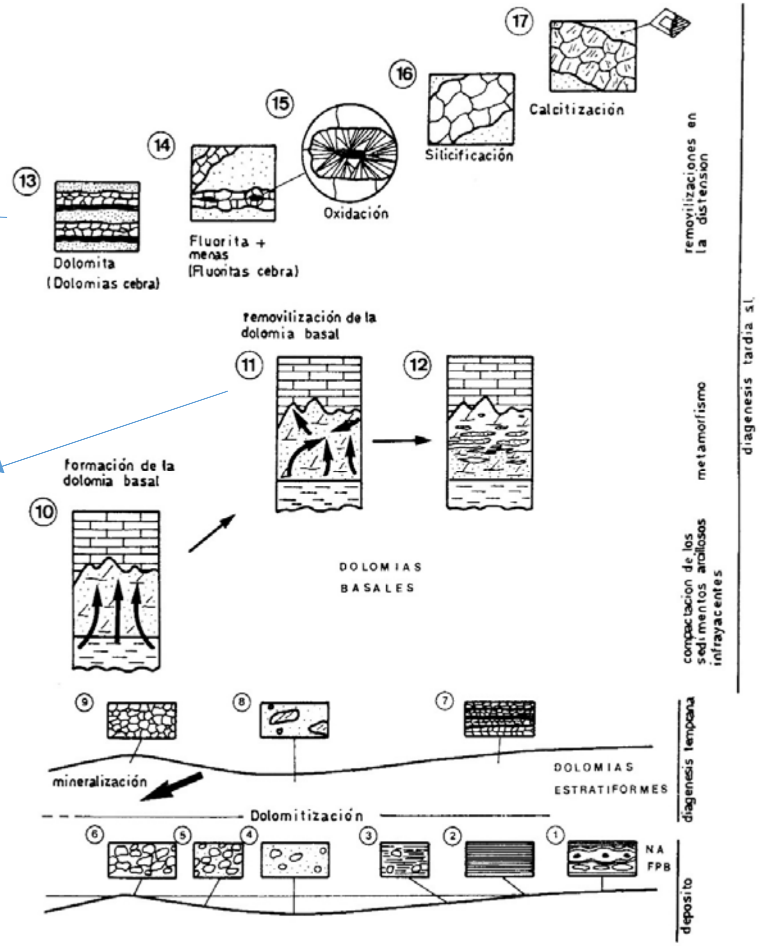


Relative positions of the Iberian and African plates during the Late Liassic (a), the Kimmeridgian (b), the Albian (c) and the Coniacian. a´: Inferred position of the Alpujárride basin.
As a result of the relative Iberia-Africa plate movements, the Alpujárride basin , as part of the African plate, was transported into a peri-Mediterranean location in the course of the Middle-Late Mesozoic.

DIAGENESIS

The clear, coarse-crystalline dolomite fill in veins created by hydraulic fracturing that tend to follow the original bedding of the rock

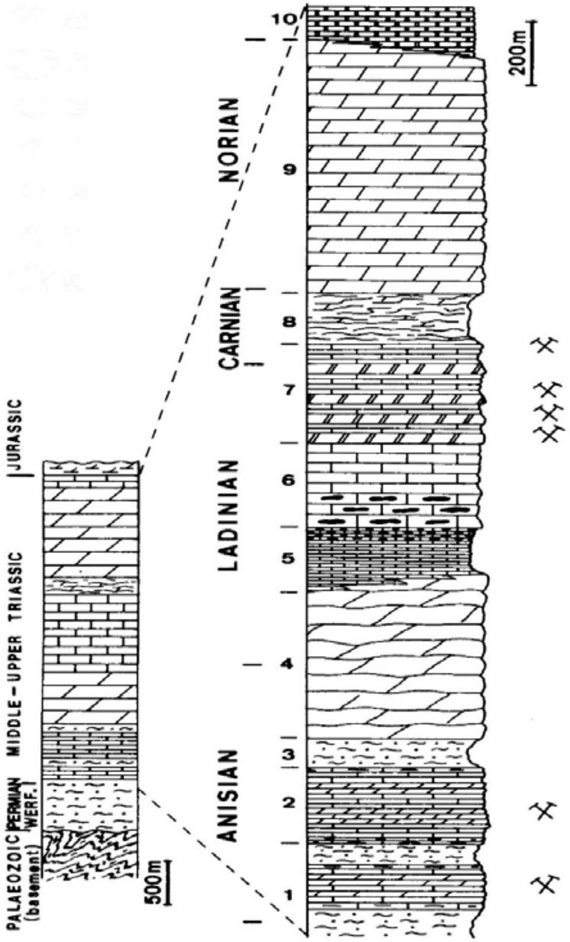
The partial recrystallization of the lower “massive” dolomite resulted in its mottled appearance



Anisian/Ladinian carbonates: Diagenetic evolution.

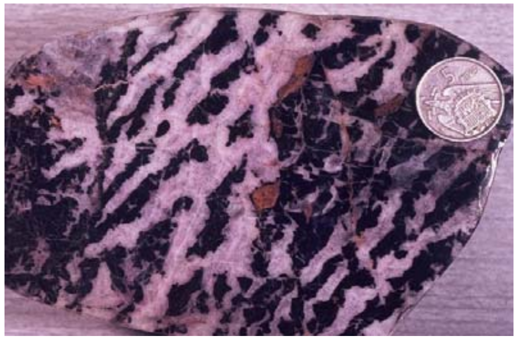
1-6: Original limestone facies. 7-9: Early diagenesis (dolomitization/mineralization). 10: Burial diagenesis (lower “massive” dolomite formation). 11-12: Low-degree metamorphism (recrystallization of the lower “massive” dolomite). 13-17: Late diagenesis (“zebra” dolomite/fluorite generation, galena/sphalerite oxidation, silica replacement and dolomite calcitization).

STRATA-BOUND ORE DEPOSITS



They are at two stratigraphic positions: (a) in the lowermost Anisian carbonates, and (b) in the uppermost Ladinian-lowermost Carnian carbonates. In both cases they are related to “pre-evaporitic” , shallow-water carbonate deposits.

They consist mainly of banded (“zebra”) fluorite and minor galena (sphalerite) ore deposits.



They replace shoal calcarenites and lagoonal micrites. They also occur inside carstic cavities within peritidal sequences.