THE STRATIGRAPHY AND PETROGRAPHY OF LA LOMA, FORTUNA BASIN, SE SPAIN

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INTRODUCTION

The goal of this project was to unravel the depositional history of the sedimentary rocks on La Loma. Three weeks were spent in the field measuring stratigraphic sections and collecting samples. Facies relationships indicate a complex depositional history of both carbonate and siliciclastic deposits. Petrographic analysis reveals a complex diagenetic history. The following is a description of the facies and a discussion of their probable depositional history.

FACIES ASSOCIATION A

1. YELLOW CARBONATE SANDSTONE FACIES: Poorly-lithified, carbonate-cemented, medium to coarse quartzose sandstone with disarticulated bivalve shells and clasts of *Porites* coral. The sandstone has a very distinctive yellow color. This facies is massive with no grading.

2. POORLY SORTED SANDSTONE/CONGLOMERATE FACIES: Poorly-sorted, medium to coarse sandstone with granule to pebble gravels and clast-supported cobble conglomerates. These lithologies are arranged in one metre thick fining upward sequences with sharp erosional lower contacts.

The clasts are mainly of sedimentary origin (about 70%), including limestones (typically bored), sandstones, chert, and shale. There are also quartzites and andesitic volcaniclastics in varying amounts, as well as scattered bivalve shells.

3. MIXED SANDSTONE FACIES: Medium bedded, very fine to granule sized terrigenous sandstone, with tests of the foraminifer *Heterostegina* and disarticulated bivalve shells. The sandstone is very poorly lithified and unstratified. Lenticular, channel-fill beds contain coarser (granule sized) clasts and a higher percentage of forams and shell fragments.

INTERPRETATION

Facies 1, 2 and 3 form a coarsening-upward sequence which is interpreted as part of a prograding delta system. The sandstones and conglomerates of Facies 2 are the uppermost deltaic sediments and are thought to represent a distributary channel complex. A major subaerial erosion surface defines the upper contact of this facies association.

These units are relatively poorly cemented and have a high porosity. The majority of the diagenetic fabrics are from the meteoric phreatic zone, although there are some early marine cements preserved.

FACIES ASSOCIATION B

4. PORITES CORAL FACIES: Thick to very thick beds of large sticks of *Porites* coral. Sub-angular to sub-rounded terrigenous clasts (1mm-4cm) of metamorphic and sedimentary rock fragments are imbedded within the boundstone. The corals are found complexly interbedded with conglomerate beds (Facies 2) and, therefore, both lithologies exhibit very irregular geometries.

INTERPRETATION

Facies Association B is dominated by *Porites* coral and conglomerate (Facies 2), with a few small beds of *Tarbellastraea* coral (described below). The conglomerates fill in karstic holes and other topographic lows in the carbonate framework. More *Porites* is found growing directly on top of the conglomerate beds. The intimate interbedding of coral and terrigenous sediment suggests a calm marine setting periodically subjected to coarse fluvial input from nearby highlands.

Diagenetically, this facies association is the most complex. Up to nine different paragenetic events were found within the pores of these units. These events alternate between those created in the meteoric environment and those in marine environments. This diagenetic complexity supports field observations that indicate small-scale sea level fluctuations.

FACIES ASSOCIATION C

5. TARBELLASTRAEA CORAL FACIES: Thickly-to very thickly-bedded *Tarbellastraea* coral. Compared to the *Porites* coral facies, the number of terrigenous clasts is relatively small. Where present, these terrigenous clasts are at the top of beds, not interspersed throughout the coral framework.

6. BIOCLASTIC SANDSTONE FACIES: White to tan, fine sandstone to granule-sized, thickly-bedded sandstone. The main bioclasts are *Tarbellastraea* coral fragments, but there is also an extremely diverse group of reef-associated fauna present.

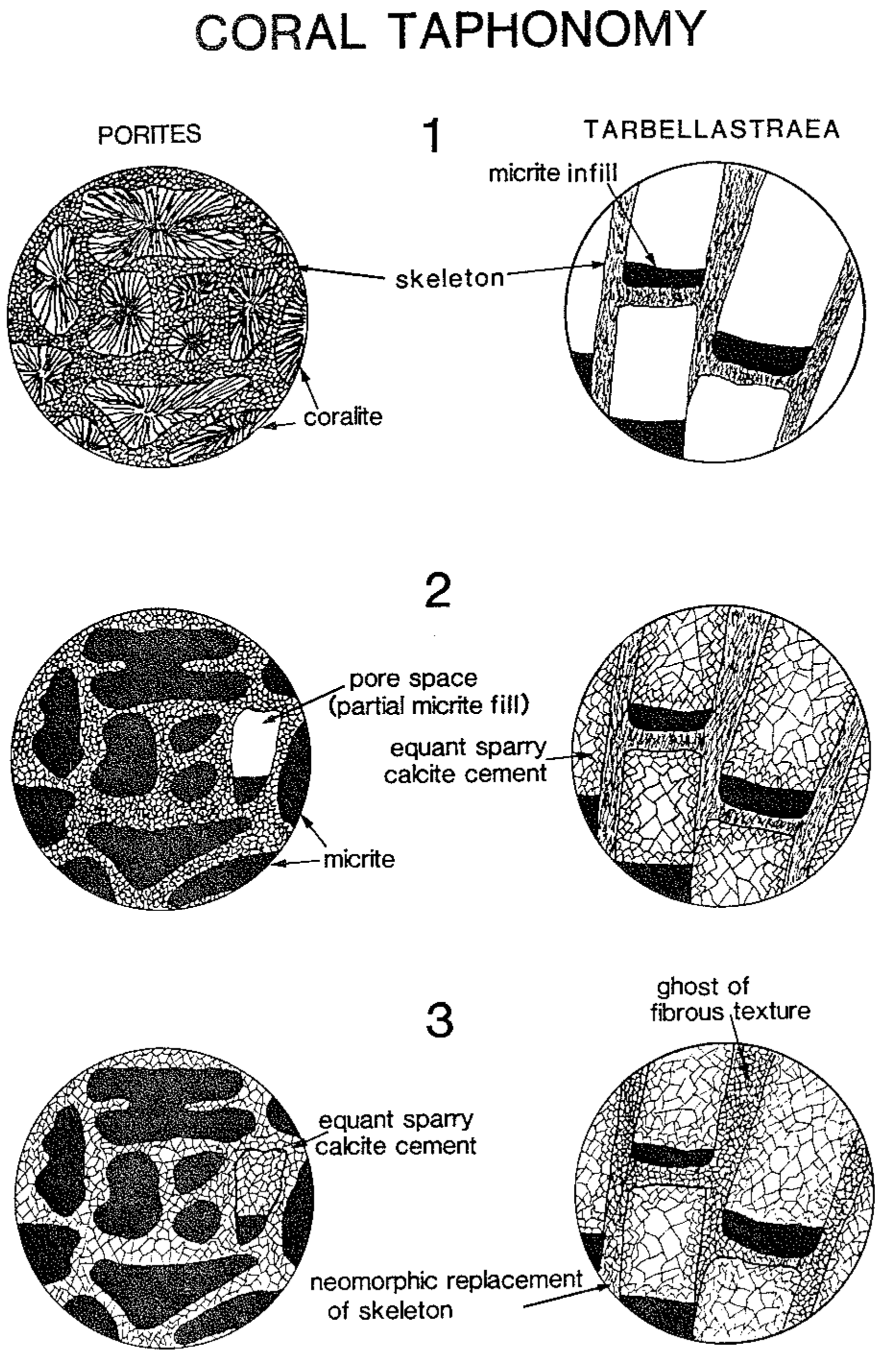
INTERPRETATION

The lack of conglomerate beds and the absence of terrigenous clasts within the boundstone suggest that the *Tarbellastraea* growth marks a time of quiescence. The presence of terrigenous clasts at the top of the beds only, suggests that the *Tarbellastraea* growth was halted when the terrigenous input was high. The bioclastic sandstone is reef debris shed from the growing *Tarbellastraea* reef.

The units in this facies association have a similar diagenetic history to those in Facies Association A. They have undergone one stage of marine cementation, followed by meteoric phreatic diagenesis.

CORAL TAPHONOMY

The taphonomic differences between *Porites* and *Tarbellastraea* are depicted in Figure 1. *Porites*, which is able to survive in adverse growing conditions, is preserved with a high percentage of micrite in its framework.



PARAGENETIC SEQUENCES

1. Unaltered coral skeleton
2. Organic decay & micrite infill
3. Skeletal recrystallization–dissolution & reprecipitation

1. Unaltered coral skeleton with partial micrite infill
2. Meteoric phreatic (and meteoric vadose ?) – equant spar with euhedral crystal terminations
3. Skeletal recrystallization with relict textures

Figure 1: Three stage diagram depicting the taphonomic differences between *Porites* and *Tarbellastraea*.

After exposure to meteoric conditons, the skeleton dissolves and is replaced by calcite. The end result is sparry calcite cement surrounding micrite infills.

The lack of micrite in the *Tarbellastraea* structure suggests that there wasn't much fine-grained sediment in the water during and immediately after growth. During exposure to meteoric conditions the majority of the "coralite pore space" was filled with sparry calcite cement instead of micrite. Despite later skeletal recrystallization from aragonite to calcite, the fibrous nature of the original aragonite skeleton is still partially preserved.

DISCUSSION

Using sedimentologic and diagenetic observations a depositional history of these rocks will be outlined below. Figure 2 is a cartoon diagram depicting these events.

The first depositional stage was the progradation of the deltaic sediments of Facies Association A (Step 1). Subaerial exposure of the delta occurred after a relative sea level fall (Step 2). The major erosion surface which truncates the deltaic sediments was created during this exposure.

A relative sea level rise resulted in flooding of the eroded delta and establishment of a carbonate reef. This first stage of coral growth consisted mainly of *Porites* (Step 3), although there was a minor amount of *Tarbellastraea* growth.

After a relative sealevel fall, the carbonate was subaerially exposed and dissolved by meteoric water to form karst topography (Step 4). The cobble conglomerates were then deposited in the dissolution holes (Step 5). The coarse grain size and facies relationships indicate a fan-delta depositonal environment. The pattern established in steps 3, 4 and 5 was repeated several times creating a complexly interbedded pattern between the *Porites* and the conglomerate (Step 6).

After the last bed of conglomerate was deposited, the sea level rose again and the *Tarbellastraea* dominated reef began to grow. Without the influx of terrigenous sediment, the carbonate grew unhindered (Step 7).

REFERENCES

Bathurst, R.G.C., 1976, Developments in Sedimentology-Carbonate Sediments and their Diagenesis, Elsevier,.

Brett, C.E, and Baird, G.C., 1986, "Comparitive Taphonomy: A Key to Paleoenvironmental Interpretation Based on Fossil Preservation", Palaios, Vol. 1, No. 3, P. 206-256.

Esteban, M., 1979/1980, "Significance of the upper Miocene coral reefs of the Western Mediterranean", Palaeogeography, Palaeoclimatology, Palaeoecology, 29, P. 169-180.

Martin, J.M., Braga, J.C., and Rivas, P., 1989, "Coral succesions in Upper Tortonian reefs in SE Spain", Lethaia 22, P. 271-286.

Pingitore, N.E., 1976, "Vadose and phreatic diagenesis : processes, products and their recognition in corals", Journal of Sedimentary Petrology, 46, P. 985-1006.

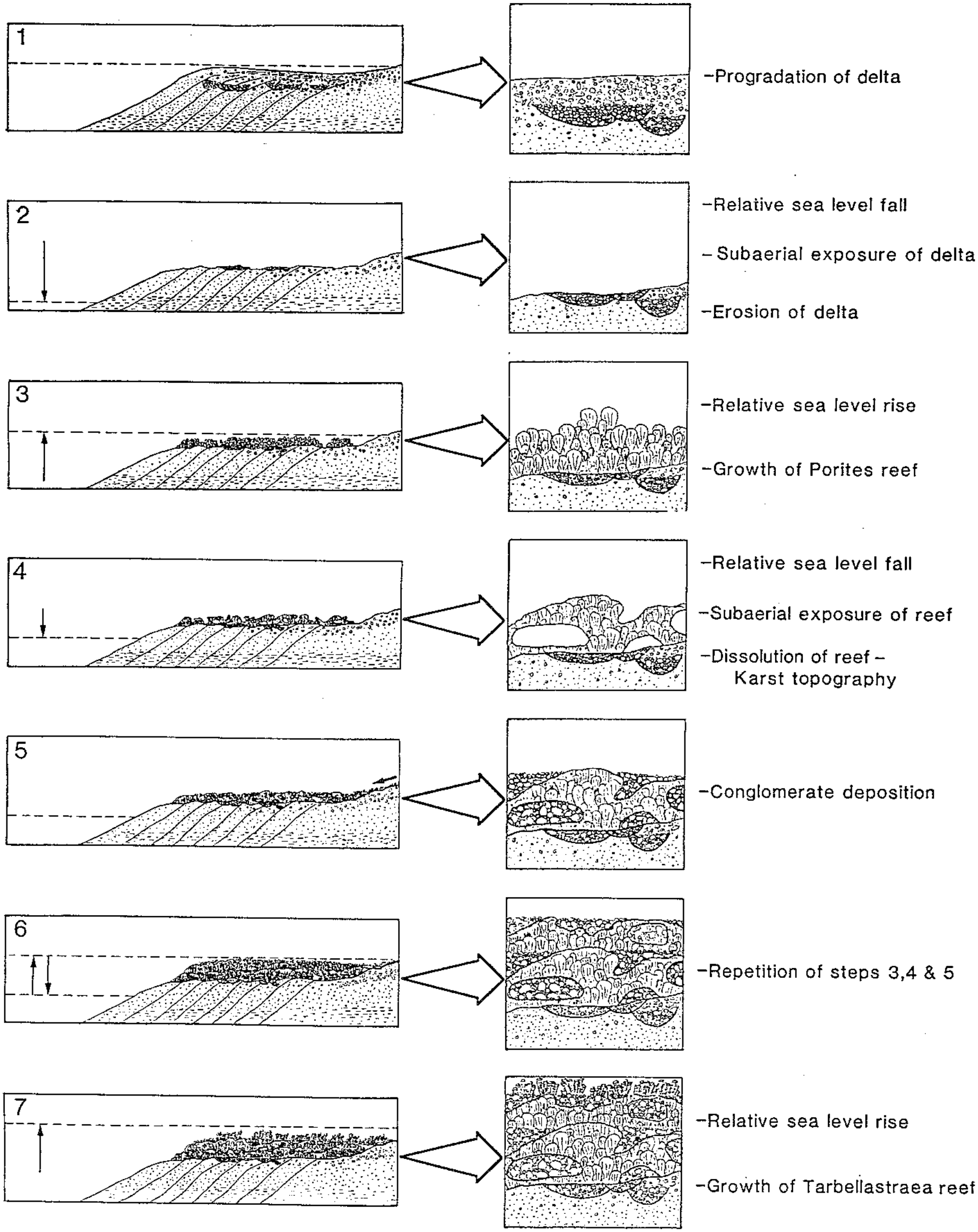


Figure 2: Cartoon diagram showing the depositional history of La Loma. The boxes on the right show enlarged sections of the corresponding events shown in the left column.

STRATIGRAPHIC EVIDENCE FOR THE RELATIVE CHANGE OF SEA LEVEL IN THE UPPER MIOCENE STRATA OF THE FORTUNA BASIN, SOUTHEASTERN SPAIN

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La Loma is a 1-km-long east/west ridge of knolls that lies in southeastern Spain's Fortuna Basin (Fig. 1). The middle segment of the La Loma ridge was the region of my study where stratigraphic sections of Miocene strata were measured and lithogenetic units were defined and correlated. A model for the area was formulated to determine the series of depositional events represented by the various lithologic units. A generalized reconstructed cross-section was made that tied in the work of Amy Steele (see this volume) with my work. It was not possible to correlate Craig Hart's data (see this volume) with mine because his units were probably stratigraphically older.

The lower 6 meters of a composite section (Fig. 2) through my area consists of fine-grained, yellow marls interbedded with thinner beds of sand. These units contain small bivalve and gastropod shells and represent moderately deep-shelf conditions. Beginning at 6.25 meters above the base of the section, there is an increasing thickness of sandy units, signifying a change from the marl's quiet, deep-water, marine environment to a sandier, near-shore beach environment. This is a coarsening-up sequence and represents a movement of the shore line to the south.

At about 12 meters above the base, pebbly and cobbly units are seen. These conglomerates were episodically brought in by rivers from an intermontane, continental drainage system. The source of these conglomerates were the Betic Mountains, which lie to the North of the study area. Three discrete horizons of gravel are found in my section. Petrographic studies show that each have the same composition of pebbles and cobbles. The clasts comprise rounded shale, sandstone, and limestone; the sand-sized matrix contains quartz, feldspar, and metamorphic rock fragments. Hence the sorting of the conglomerates is poor.

The next stage of deposition consists of in situ *Tarbellastraea* coral bioherms. These developed on top of the conglomerates and denote that there was a fairly rapid relative rise in the level of the sea. The terrigenous conglomerates were rapidly covered by marine waters. The bioherms consist of *Tarbellastraea* corals, echinoids, gastropods, bivalves, and a small number of red-coralline algae. Limonite staining on some corals signify subaerial exposure where the corals were next to a paleovalley cut by a channel. Some units of strata contain *Heterostegina*, a large, shallow-water foraminifer common to Miocene reefal sediments of southeastern Spain (Mankiewicz, personal communication).

Figure 3, a schematic cross-section, shows the cyclical repetition of facies. The sequence of coarsening-up units, conglomerate deposition after paleovalley channel cutting, and reef growth above the conglomerate is repeated three times in the sequence of my study area. The deepest channel cut is HG-2 (estimated at more than 25 meters deep) from Amy's area. This channel cut is capped by conglomerate at the top and contains cycles of conglomerates that fine up to sand. The three horizons of conglomerates were determined to be deposited by fresh-water channels because of the lenticular geometry above an erosive surface, and the lack of fossils, except at the very top. Here at the top, oysters were found to be encrusting pebbles. They attached themselves to the pebbles after the cessation of channel flow when the gravel acted as a hardground for the *Tarbellastraea* mounds. The downcutting event that was accompanied by conglomerate deposition must have been from allocyclic causes, i.e. not normal lobe switching or other autocyclic mechanisms. Two types of allocyclic mechanisms are considered: tectonic and eustatic. Only further work in Spain and surrounding regions such as southern France and northern Africa would establish the relative effectiveness of either one or both of these mechanisms.

The model developed from my research proposes that there were many fluctuations of the relative level of the sea in the Fortuna Basin. The lower, coarsening-up units of each cycle suggest offshore marine to beach deposition followed by fluvial conglomerates at the top. This indicates a slow then rapid drop in the relative position of the sea. Rivers then cut paleovalleys which filled with conglomerate. The level of the sea must have then quickly risen to cover the conglomerates which became hardgrounds for the corals to