A PETROGRAPHIC STUDY OF A MIOCENE REEF, LOS BANOS DE FORTUNA, SOUTHEASTERN SPAIN

Patricia L. Smith
Smith College
Northampton, Massachusetts, 01063

Introduction

Field research was conducted in southeastern Spain on Thornbush Knoll, located outside the town of Los Banos de Fortuna, which is located near Fortuna in the Fortuna Basin. Field work on the knoll involved measuring several vertical sections of the Mesozoic limestone and the unconformably overlying Miocene rocks, and measuring the strata laterally. The irregular surface of the Mesozoic/Miocene contact was noted and a vertical section was made through a large paleochannel exposed on the southeast side of the knoll. Sketches, field photographs, hand specimens, and core samples were taken. The fourteen hand specimens and eighteen core samples collected from the *in situ* reefal unit were used for this study. Cathodoluminescence and petrographic studies of these samples were conducted to determine the paleoenvironment of deposition and to identify the diagenetic history of the Late Miocene reefal complex exposed on Thornbush Knoll.

Stratigraphic Sequence of the Knoll

The base of the vertical section (See Figure 1), is marked by a fine-grained Mesozoic limestone that has been either folded or tilted. An angular unconformity separates the Mesozoic rocks from the overlying Miocene strata. The contact between the Mesozoic and Miocene is very irregular due to erosional channels; on the southeast side of the knoll a large paleochannel is located. The strata within this channel contain a sequence of a fine-grained limestone layer overlain by a *Porites* layer, and topped by a fine-grained layer that includes red coralline algae (See Figure 2). These layers pinch out laterally. The basal Miocene rocks contain clasts derived from the underlying Mesozoic limestone; also large fossil oysters (*in situ*?) were noted at the Mesozoic/ Miocene contact. A burrowed non-resistant layer of fine-grained sand occurs on top of the basal unit. Fossilized oysters, rounded pebbles, and pieces of chert were noted within the rock around the area located over the southeastern paleochannel. The next unit is a very fine-grained homogeneous limestone that is well exposed, followed by a unit that was not well exposed. Within this unit a variety of fossils were noted including: bivalves, red coralline algae, and *Porites*. Oysters and oyster fragments were found lying on the surface of the unit and embedded in the rock itself. Above this layer, topping the knoll is an *in situ* reefal complex. The lowest bed of the reefal complex is a fine-grained limestone mostly made up of red coralline algae forming the subsrate on which the branching coral *Porites* grew. This in turn gave the coral *Tarbellastraea* a more solid substrate to grow on. This cycle is then repeated.

Petrographic Analysis of the Reefal Rocks

As mentioned above, there is a series of repeated beds in the reefal complex; a limestone with an abundance of red coralline algae, then a *Porites* layer, which is capped by *Tarbellastraea*. The fine-grained limestone contains encrusting red coralline algae and rhodoliths, bivalves (including oyster fragments), gastropods, miliolid foraminifera, and echinoderm fragments. Included in the overlying *Porites* layer are some bivalves, benthic foraminifera, and red coralline algae. The *Tarbellastraea* layer, however, does not include many of the organisms associated with the other two beds. Non-skeletal grains and non-carbonate grains were not noted in any of the thin sections studied.

The matrix of all the samples is micrite. The matrix fill of the corallites and chambers in the gastropods and foraminifera is also micrite. According to Tucker (1981), lime mud can be the result of bioerosion of carbonate grains by algae or boring sponges; the breakdown of skeletal grains by wave or current action; or biochemical precipitation from algal photosynthesis and decompostion. These silt or clay size particles can then be carried in suspension by turbid waters. If the turbidity is great, then larger sized grains can also be transported along with the lime mud. Upon reaching a low energy environment, deposition of both the silt and grains will happen simultaneously creating a matrix supported fabric.

The micrite in these Miocene rocks has gone through degrees of aggrading neomorphism causing an increase in crystal size (See Figure 3). This process is where the original crystals are being consumed and being replaced at the same time by new crystals of the same mineral (Folk, 1965). Scoffin (1987) states this process commonly occurs in a freshwater environment. The criteria used for determining aggrading neomorphism followed Bathurst (1975) and Scoffin (1987):

1. Increase of cystal size
2. Patches of micrite within a matrix of coarsening crystals
3. Diffused contact between micrite and coarsening crystals
4. Diffused grain boundaries or parts of the internal structure is diffused
5. Wavy intercrystalline boundaries of the crystals

The cathodoluminoscope study determined the crystals to be non-luminescent. By staining the thin sections with a mixture of alizarin red sulphonate and potassium ferricyanide, it was determined that only one generation of cementation occured within these Miocene rocks; a non-ferroan drusy sparite. Drusy calcite is a phreatic freshwater cement that occurs with the dissolution and replacement of aragonitic skeletal grains (Tucker, 1981). The pore space created by the dissolution is filled in with cement that grows from the pore wall and becomes coarser towards the center of the void. This drusy mosaic is noted in primary pore spaces as well as in the secondary pore spaces of the thin sections. The primary pore spaces noted in the samples are the conceptacles of the red coralline algae. The secondary pore spaces created after deposition, are the areas of leached aragonitic grains, such as the skeletal walls of the corals, and the shells of the bivalves and gastropods.

All the thin sections exhibit alveolar texture (See Figure 4). This is a term introduced by Esteban (1979), that is considered to be evidence of subaerial exposure. The alveolar texture is a type of caliche cement formed in association with plant root hairs. The texture is identified by sinuous lines of micrite forming irregular pore spaces between grain contacts. The samples of this study exhibit the alveolar texture only in the interparticle pore spaces.

Conclusions

A subtidal zone of normal marine waters in a lagoonal area was determined as the paleoenvironment for the reefal complex on Thornbush Knoll. The presence of *Porites* and *Tarbellastraea,* red coralline algae and echinoderms suggests normal marine waters; whereas the presence of miliolid foraminifera, gastropods, and the simultaneous deposition of silt and grains indicate a low energy environment like that of a back shelf lagoon. The growth sequence of *Tarbellastraea* on top of *Porites* demonstrates a rise in sea level. Within the transgression there were periods of minor sea level falls, allowing a concentrated deposition of silt to occur and the beginning of another cycle.

The diagenetic history of the reefal complex supports a regression of normal marine waters to a freshwater setting as indicated by the dissolution of skeletal grains composed of aragonite, aggrading neomorphism, and drusy sparite. Subaerial exposure of the land is indicated by the alveolar texture. It is determined that the last stage of diagenesis is the drusy calcite cement, as shown by its presence in all the pore spaces. The sequence of events--a transgression interrupted by minor sea level falls, followed by a regression--that effected the late Miocene reefs is as follows:

1. Deposition of silt and biogenetic grains in shallow normal marine waters
2. Growth of the coral *Porites*
3. Growth of the coral *Tarbellastraea*
4. Oscillations of shallow sea level falls
5. Repeat of steps 1 through 4
6. Influx of freshwater/uplift of land
7. Dissolution of aragonitic grains
8. Aggrading neomorphism
9. Drusy sparite cementation
10. Subaerial exposure
11. Continued influx of freshwater

References Cited

Bathurst, Robin G. C., 1975. Carbonate sediments and their diagenesis. Elsevier Scientific Publishing Company, New York, pp. 475-503.

Folk, Robert L., 1965. Some aspects of recrystallization in ancient limestones. In: Pray, Lloyd C. and Murray, Raymond C. (Editors), Dolomitization and limestone diagenesis, a symposium. Society of Economic Paleontologists and Mineralogists, Special Publication, 13: 14-48.

Esteban, M., 1979. Significance of the Upper Miocene coral reefs of the western Mediterranean. Palaeogeography, Palaeoclimatology, Palaeoecology, 29: 169-188.

Scoffin, Terence P., 1987. An introduction to carbonate sediments and rocks. Chapman and Hall, New York, pp. 103-105, 129-130.

Tucker, Maurice E., 1981. Sedimentary petrology: an introduction. Blackwell Scientific Publications, Boston, pp. 116-118.

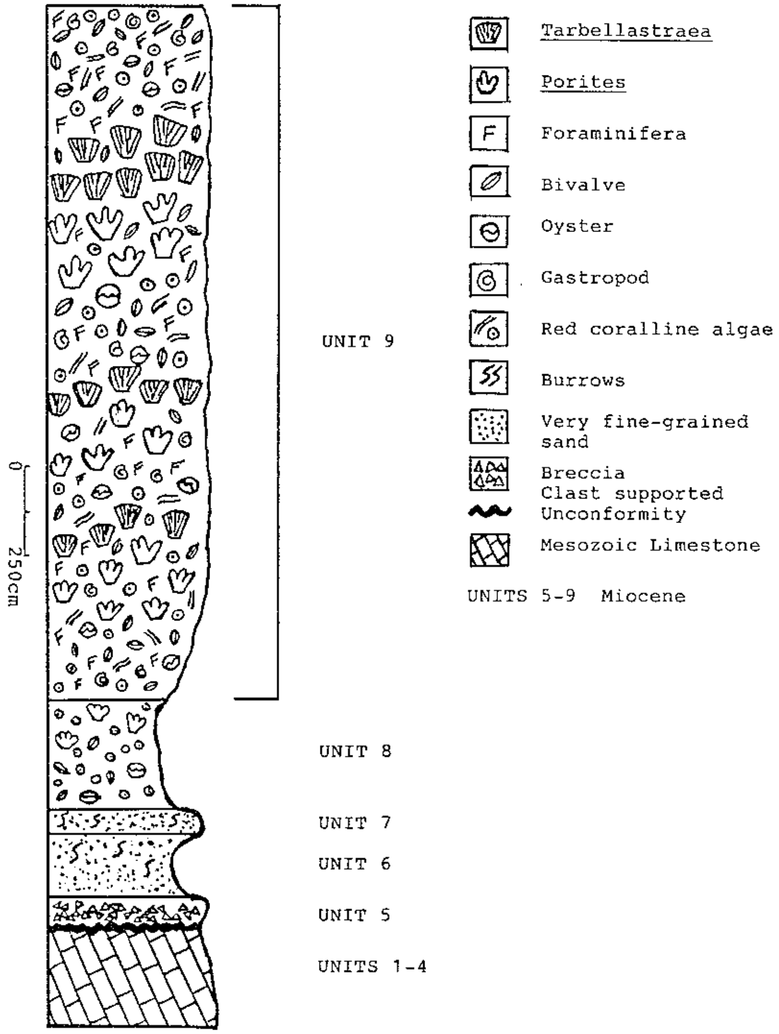

Figure 1. A vertical section of Thornbush Knoll.

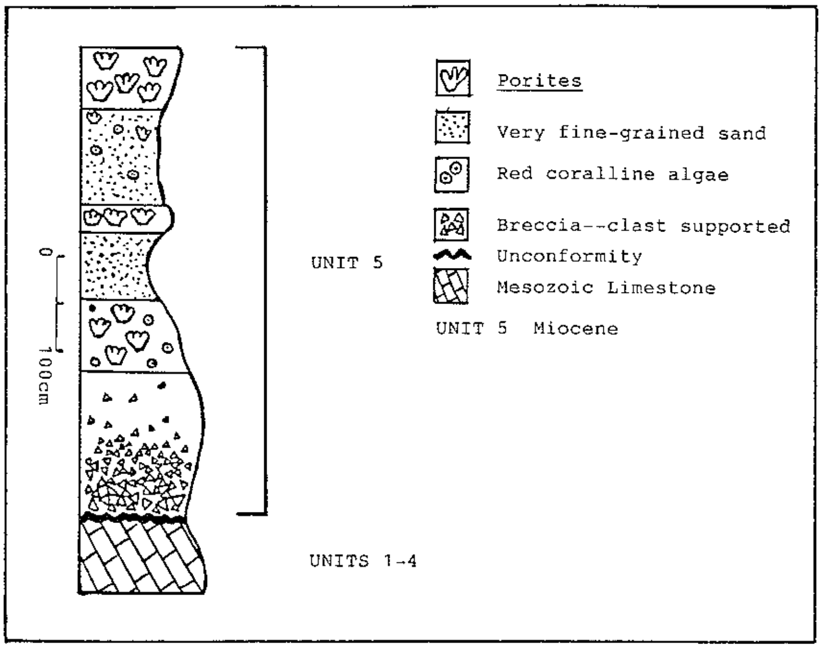

Figure 2. Vertical section through the center of the paleochannel on the southeast side of Thornbush Knoll.

Figure 3. Aggrading neomorphism of micrite.

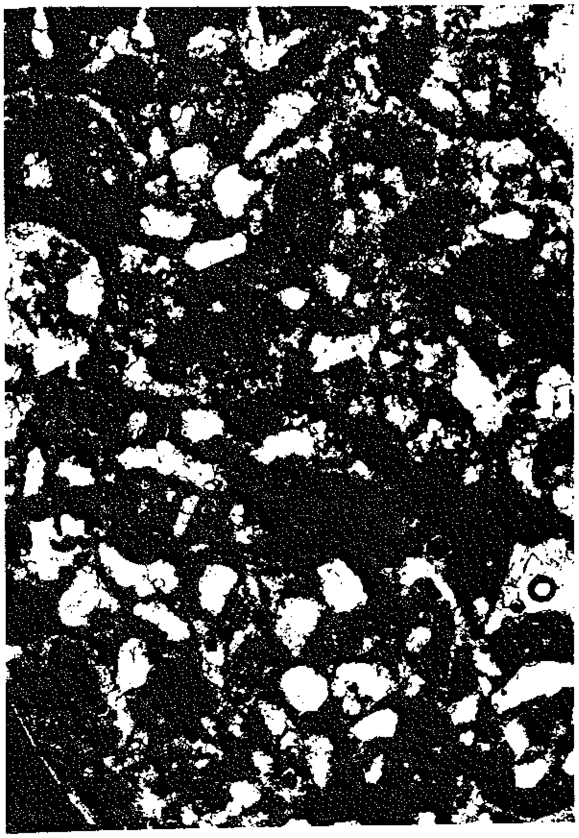

Figure 4. Alveolar texture in interparticle pore space.