LATE MIOCENE REEFS OF SOUTHEASTERN SPAIN

Faculty

Carol Mankiewicz, Beloit
Carl Mendelson, Beloit
H. Allen Curran, Smith
Brian White, Smith

Students

Craig Hart, Colorado
Cynthia Knight, Amherst
Steven McKnight, Pomona
Genga Thavi Nadaraju, Wooster
Thomas Olszewski, Franklin and Marshall
Shannon Parsons, Beloit
Patricia Smith, Smith
Amy Steele, Williams
Bronwyn Wallace, Smith

Visitor

Paul Myrow, Colorado

THE LATE MIOCENE OF SOUTHEASTERN SPAIN: SEDIMENTOLOGY, PALEOECOLOGY, AND DIAGENESIS

Carol Mankiewicz and Carl V. Mendelson
Department of Geology
Beloit College
Beloit, WI 53511

Introduction

The upper Miocene strata of the Mediterranean region have recently aroused great interest among geologists, in part because these strata predate the "salinity crisis," a time about 5 or 6 Ma when the Mediterranean sea level fell markedly. The magnitude of sea-level fall remains a much-debated issue (Drooger, 1973; Dietz and Woodhouse, 1988). Prior to the salinity crisis, an archipelago of reefs developed throughout the western Mediterranean; no coral reefs survived into post-Miocene time.

Miocene reefs are abundant throughout the world, but most are buried. The Mediterranean region features the best exposures of these reefs, and in southeastern Spain the Miocene reefs and associated strata have escaped significant deformation.

Geologic Setting

The Betic Cordillera, westernmost of the Alpine chains, dominates the geology of southeastern Spain today, and the same was probably true during the Miocene. The Betic Cordillera comprises four lithologically and structurally distinct geologic provinces; lithologies of these provinces range from metamorphic to evaporitic to unmetamorphosed sedimentary rocks (Ager, 1980). Alpine tectonic activity decreased by middle Miocene time; the consequent decline in terrigenous clastic influx allowed coral and algal reefs to flourish in postorogenic Neogene basins within the Cordillera. The terrigenous clastic component of these basins reflects the geologic province in which the reefs grew.

During the middle Miocene (Figure 1), no connection existed between the Atlantic Ocean and Mediterranean Sea at the Strait of Gibraltar. Instead, two seaways connected the two bodies of water: the Betic seaway to the north and the Rif seaway to the south. The two seaways remained open until sometime in the latest Miocene-earliest Pliocene, the time of the salinity crisis; afterward, the Strait of Gibraltar began its current role as the sole Atlantic-Mediterranean connection (Hsü and others, 1977). During the middle to late Miocene, therefore, the waters presumably became progressively more restricted. Esteban (1979) suggested that the paleontology of the reefs reflects the restricted waters of the impending salinity crisis or perhaps the influx of cold Atlantic waters. Thus, low biotic diversity typifies younger Miocene reefs developed under conditions less suitable for coral and algal growth.

Mankiewicz (1987) suggested that numerous relative sea-level changes affected biotic diversity and distribution as well as sedimentologic and diagenetic characteristics of the Miocene reefs and associated strata. Sea-level fluctuations would alter sediment supply, water quality, and water exchange between basins.

Research Projects

The project began with a six-day tour of some of the more representative and spectacular middle to upper Miocene exposures between the towns of Níjar and Fortuna (Figure 1). The goal was to introduce the students and faculty to the regional geology so that they could better place their individual projects into the "bigger picture" of events during Miocene time in southeastern Spain. Miocene successions near Níjar (Figure 2) display characteristics typical of uppermost Miocene reefs and associated strata: low-diversity fringing reefs, dolomitization, and considerable fine-grained terrigenous clastic material (Dabrio and others, 1981; Mankiewicz, 1987). The successions near Fortuna (Figure 3) are mainly middle to upper Miocene. They are characterized by reefs of higher diversity that are not dolomitized and that typically establish themselves on conglomerate-covered platforms (Santisteban, 1981; Santisteban and Taberner, 1983; Mankiewicz, 1987).

During the Miocene an archipelago occupied what is now southeastern Spain. Thus, the geology of each island of the archipelago developed independently as a function of island size and elevation, geographic location with respect to water currents and other land masses, etc. On some islands reef sedimentation dominated, whereas on others little evidence of reef growth is preserved. Each island, however, was affected by regional and, perhaps, worldwide changes (e.g., water quality and sea level). The similarities and differences in the geology of each isolated area provided interesting and challenging research problems for the Keck participants.

The students chose to work in four different areas, each of which was isolated from the others during Miocene time. Students documented the rocks in their area by means of stratigraphic sections, detailed drawings, and photography, and they collected numerous specimens for study during the school year. The four areas and the types of research projects are discussed below.

(1) Five students concentrated on an elongate ridge (about 1 km by 0.2 km) that we informally referred to as "La Loma" (the ridge) (Figures 3, 4). La Loma offers a variety of rock types ranging from fine-grained marls to cobble conglomerates to in-place corals.

Three of the five students concentrated on sedimentology and stratigraphy. Amy Steele, Cynthia Knight, and Craig Hart divided the ridge into three roughly equal parts and each chose one for detailed, individualized study. During the school year the students focused on the petrography and petrology of their rock specimens. Their studies document the variation and similarities within a single area.

Two other students, Genga Thavi (Devi) Nadaraju and Shannon Parsons, studied paleoecologic aspects of La Loma, concentrating on the change from nonreef to reef sedimentation. Devi focused on borings in corals and conglomerates, and Shannon interpreted the stratigraphic relationships between the corals and conglomerates.

(2) Three students worked in an area called El Desastre (the disaster) (Figure 3). Patricia Smith addressed the problem of diagenesis of coral limestones on a hill informally called "Thornbush Knoll." Patricia and Brian White, her advisor, were mainly interested in the sedimentology and diagenesis above the Cretaceous-Miocene unconformity, an irregular surface that places shallow-water sediments directly over deep-water carbonate rocks. Patricia continued during the school year with cathodoluminescence and petrographic studies of her samples.

Two students studied a large area (about 1 km^2) that had formerly been described only as reef-slope sediments; they informally named the area "El Jamón" (the ham). Thomas Olszewski focused on the paleontology, and Steven McKnight studied the sedimentology. They discovered spectacular outcrops of in-place corals that had not been reported previously in the literature. Petrographic studies during the school year provided information on foraminifer taphonomy (Thomas) and diagenesis (Steven).

(3) and (4) Bronwyn Wallace studied trace fossils in two areas to determine their distribution and to help interpret environment of deposition. She worked at El Arco (the arc) (Figure 3), an arc-shaped deposit of siliciclastic sediments. The other area of interest was near the town of Níjar (Figure 2). Using measured sections described in Mankiewicz (1987), Bronwyn and H. Allen Curran, her advisor, documented types and distribution of trace fossils.

Our research group thanks the Comisión Nacional de Geología de España for granting us permission to work in Spain, and the Keck Foundation for providing funding and the opportunity to work with students and faculty from several institutions.

References

Ager, D.V., 1980, The geology of Europe: New York, John Wiley, 535 p.

Dabrio, C.J., Esteban, M., and Martín, J.M., 1981, The coral reef of Níjar, Messinian (uppermost Miocene), Almería Province, S.E. Spain: Journal of Sedimentary Petrology, v. 51, p. 521-539.

Dietz, R.S., and Woodhouse, M., 1988, Mediterranean theory may be all wet: Geotimes, v. 33, no. 5, p. 4.

Drooger, C.W., 1973, The Messinian events in the Mediterranean, a review, *in* Drooger, C.W., ed., Messinian events in the Mediterranean: Amsterdam, North-Holland, p. 263-272.

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

Fernex, F., Magné, J., and Mongin, D., 1967, The palaeogeography of the eastern Betic ranges of southern Spain during the Cenozoic, *in* Adams, C.G., and Ager, D.V., eds., Aspects of Tethyan biogeography: Systematics Association Publication 7, p. 239-246.

Hsü, K.J., Montadert, L., Bernoulli, D., Cita, M.B., Erickson, A., Garrison, R.E., Kidd, R.B., Mèlierés, F., Müller, C., and Wright, R., 1976, History of the Mediterranean salinity crisis: Nature, v. 267, p. 399-403.

Mankiewicz, C., 1987, Sedimentology and calcareous algal paleoecology of middle and upper Miocene reef complexes near Fortuna (Murcia Province) and Níjar (Almería Province), southeastern Spain [Ph.D. thesis]: Madison, University of Wisconsin, 341 p.

Santisteban, C., 1981, Petrología y sedimentología de los materiales del Mioceno superior de la cuenca de Fortuna (Murcia), a la luz de la "teoría de la crisis de salinidad" [Ph.D. thesis]: Barcelona, Universidad de Barcelona, 725 p.

Santisteban, C., and Taberner, C., 1983, Shallow marine and continental conglomerates derived from coral reef complexes after desiccation of a deep marine basin: the Tortonian-Messinian deposits of the Fortuna Basin, SE Spain: Journal of the Geological Society of London, v. 140, p. 401-411.

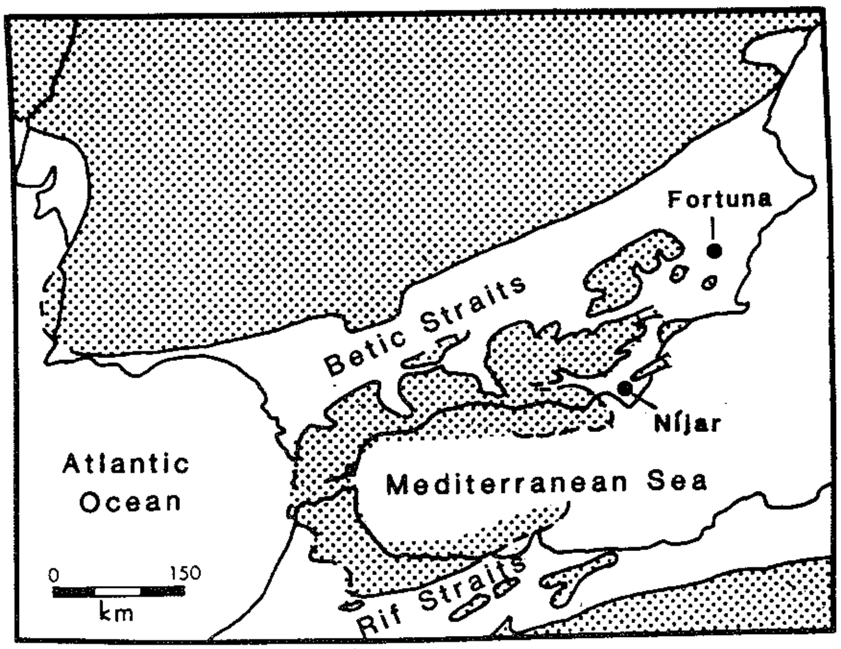

Figure 1. Middle Miocene paleogeography of the western Mediterranean; land depicted in stippled pattern (after Fernex and others, 1967). The towns of Níjar and Fortuna are located near the study areas.

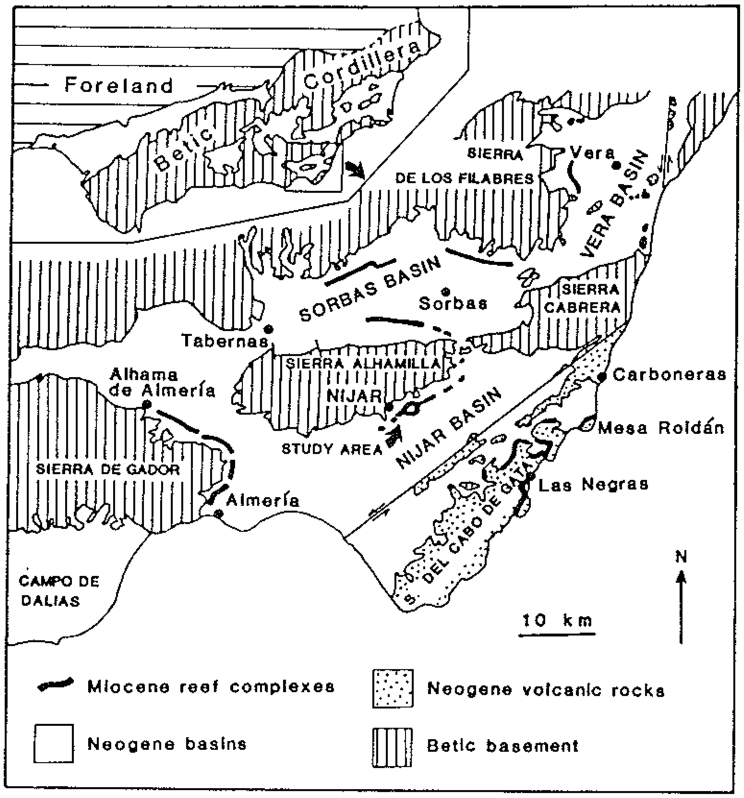

Figure 2. Location map showing distribution of upper Miocene reefs in southeastern Spain (after Dabrio and others, 1981). Arrow points to study area near the town of Níjar.

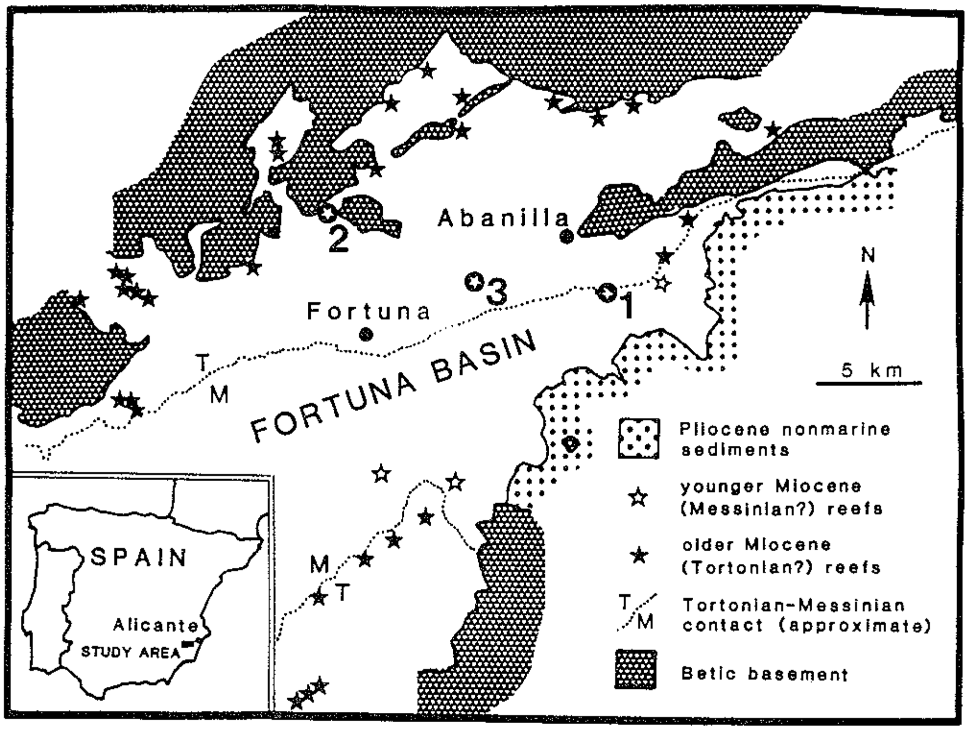

Figure 3. Geologic units of the Fortuna area, northeastern part of the Fortuna Basin (after Santisteban, 1981). Circled stars (✪) indicate the study areas: (1) La Loma, (2) El Desastre (including Thornbush Knoll and El Jamón), (3) El Arco.

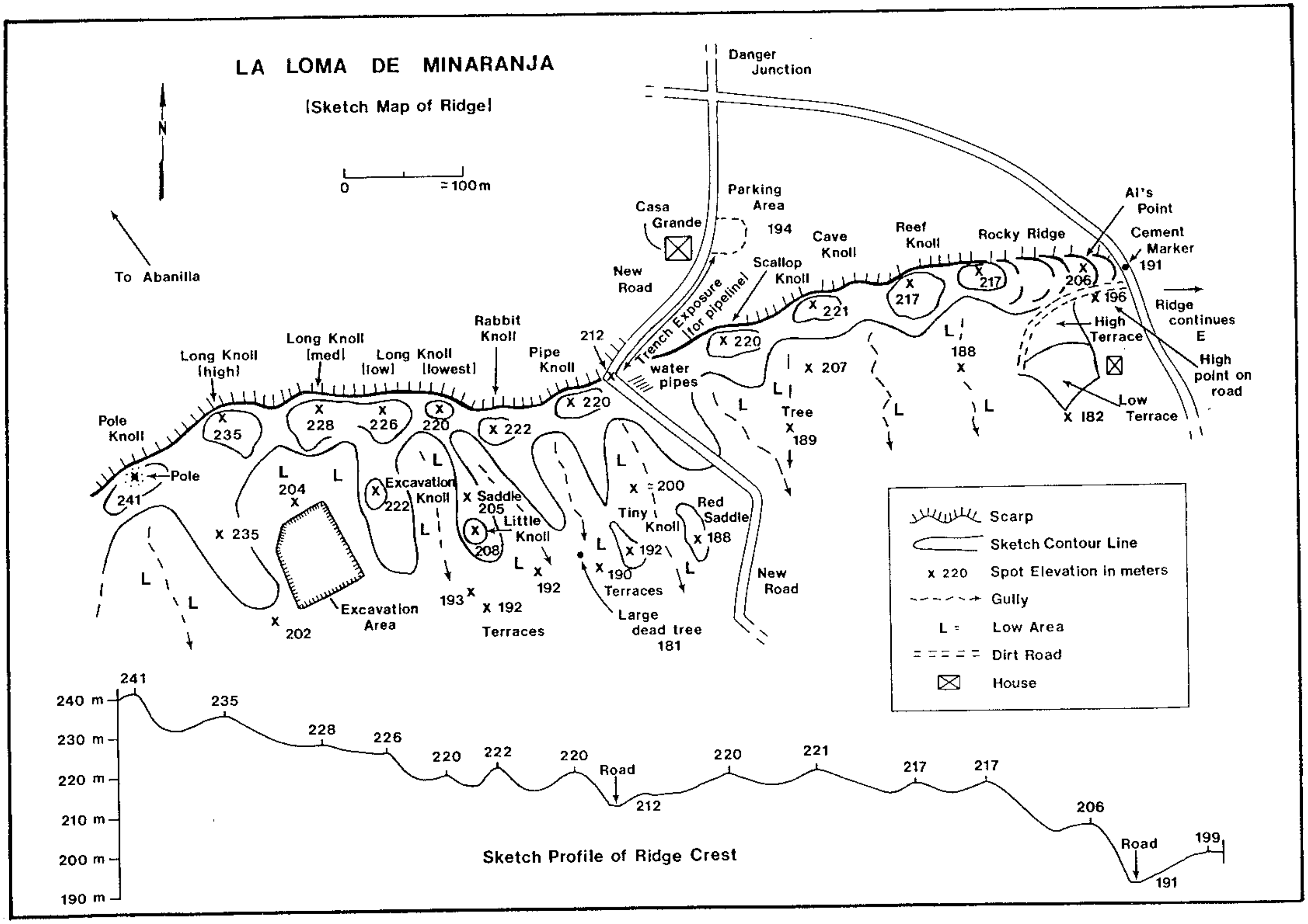

Figure 4. Sketch map and vertical profile of La Loma, based on field sketches and pace-and-compass mapping by H. Allen Curran and Carol Mankiewicz. Compiled by H. Allen Curran; drafted by Denise Descoteau.