UNCONFORMITY BETWEEN CRETACEOUS AND EOCENE ROCKS IN CENTRAL-WESTERN PUERTO RICO: A CONCEPT REJECTED

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ABSTRACT

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A major unconformity between rocks of Late Cretaceous and Eocene age in central-western Puerto Rico was previously reported. Recent work suggests that the evidence cited is invalid:
(1) because sediments which were interpreted as a basal conglomerate appear to be a fault breccia related (in all areas but one) to gravity sliding;
(2) because more extensive mapping has shown that the lithologically distinct Anón Formation, known locally to contain fossils of early Tertiary age, interfingers conformably with formations which contain fossils of Late Cretaceous age.

The evidence indicates that deposition in central-western Puerto Rico has been continuous from Late Cretaceous to at least Middle Eocene.

INTRODUCTION

A profound unconformity between rocks of Late Cretaceous and Eocene age exists, according to MATTSON (1966, 1967, 1968b), in central-western Puerto Rico (Fig. 1). Evidence cited to support this concept consists of (1) "a talus or coastal cliff deposit", that is, a transgressive basal conglomerate, that truncates Upper Cretaceous sedimentary and plutonic rocks (MATTSON, 1966, p. 49-50); and (2) the absence, in central-western Puerto Rico of a thick sequence of rocks between rocks of early Tertiary age and the Robles Formation (MATTSON, 1967, p. B10; 1968b), a unit of Albian and Cenomanian age where known in east-central Puerto Rico (DOUGLAS, 1961, p. 476; OTÁLORA, 1961, p. 45, 60-61, 63-64).

DISCUSSION

The "talus or coastal cliff deposit" (MATTSON, 1966, p. 50) was originally named and mapped by PESSAGNO in the Jayuya quadrangle (1961, p. 71, pl. 1) as the Miramar Member of the Naranjo Formation. It was subsequently renamed the Miramar Conglomerate Member of the Rio Prieto Formation for outcrops in the Jayuya quadrangle (Fig. 2) (MATTSON, 1967, p. B24) and was raised in rank and renamed the Miramar Formation in the adjacent Rio Descalabrado quadrangle (GLOVER & MATTSON, 1967, p. A33). A lithofacies like that in the type area was also mapped in the Ponce quadrangle (KRUSHENSKY & MONROE, 1975). The rock is well exposed in the original type area (PESSAGNO, 1960, p. 71), where it consists of a hematitized dark-red slickenside-riddled breccia in which a clay ma-

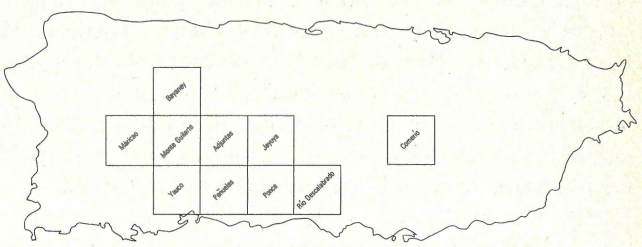

Fig. 1
Outline map of Puerto Rico showing locations of quadrangles discussed.

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trix encloses abundant sharply angular and commonly tabular clasts of resistant porphyritic volcanic rocks like those in the immediately underlying Achiote Conglomerate of Santonian to Maastrichtian age. Clasts vary from those in which all surfaces are planar and meet at moderate to high angles to those in which planar and rounded surfaces are both present. Uncommonly, single well-rounded pebbles and cobbles have been fractured and partly offset along planar surfaces. Generally, all surfaces of clasts coarser than very coarse sand-size are coated with hematite, and all clast surfaces are slickensided. Sparse angular to well-rounded clasts of pale-pink algal calcarenite like that in the basal few meters of the overlying Cuevas Limestone of Middle Eocene age (Sachs & Cole, *in* MATTSON, 1967, p. B27) are also present. The breccia matrix in the type area of the 'Miramar' constitutes as much as 50% of the rock and consists of hematite-red clay shot through with irregularly undulating, areally restricted, and anastomosing slickenside surfaces. Outcrops of the breccia along route 149 north of Juana Diaz and south of Gayabal near the eastern border of the Ponce quadrangle (KRUSHENSKY & MONROE, 1975) contain three shear zones that dip at about 25° to 30° S. Like the areally restricted slickenside surfaces noted in the clay matrix, these shear zones are irregularly anastomosing. None can be regarded as bedding planes. Outcrops of the breccia between the Cuevas Limestone and the Maravillas Formation of Late Cretaceous age (MATTSON, 1967, p. B18) north of the Río Guayo on the north-central border of the Ponce quadrangle and extending into the Jayuya quadrangle consist of extremely angular rhombohedral clasts of dark-red mudstone identical to the underlying jointed Maravillas Formation. A few angular clasts of pale-pink algal calcarenite like that in the overlying Cuevas Limestone are also enclosed in a dark-red slickenside-riddled clay matrix.

The lower surface of the Cuevas Limestone, where exposed in the Ponce and Jayuya quadrangle, is smoothly undulating and shows a local relief of 1 m vertically in 1 m horizontally. It is not gradational into the underlying 'Miramar' as indicated by MATTSON (1967, p. B25). Slickenside-riddled breccia is plastered up into the irregular surface and into joints in the limestone. Reconnaissance study of the Miramar Fm in the Río Descalabrado (GLOVER & MATTSON, 1973) quadrangle indicates that, in many areas, the rock mapped differs in no significant manner from that described above. Clasts, where present in the generally deeply weathered rock, in outcrops north of Escuela Tijeras (1.25 km map distance west of Juan Diaz on route 14) show both curved and planar slickensided surfaces that meet at moderate to high angles. Clasts are commonly small (6-15 cm, rarely as much as 2 m); the abundant clayey matrix is dark hematite red and is shot through with slickensides.

The 'Miramar', mapped by GLOVER & MATTSON (1973) 0.86 km north of Escuela Tijeras on route 551, is also like that in the type area, but clasts commonly consist of angular limy siltstone-sandstone like that locally present in the Maravillas Formation. The 'Miramar' in the Cañas Arriba area (4.35 km distance east of Juana Diaz) is locally like that between the Maravillas and the Cuevas in the northern part of the Ponce quadrangle; that is, clasts are composed of highly angular rhombs of siltstone-sandstone like that in the Maravillas, suspended in a silty slickenside-filled matrix. The major part of the 'Miramar' there, however, is lithologically indistinguishable from the Maravillas Formation.

GLOVER (1971, p. 52) noted that thick-bedded oyster-bearing limestone occurs as lenses in the 'Miramar' of the Rio Descalabrado quadrangle. Similar limestone with abundant reeflike masses of *Crassostrea* sp. is present near the top of the Pastillo Member of the Lago Garzas Formation (KRUSHENSKY & MONROE, in press), in the border area between the Adjuntas and Peñuelas quadrangles. Although MATTSON (1968a) mapped these beds as part of the 'Robles' in the Adjuntas quadrangle, the *Crassostrea*-bearing limestone there is clearly in fault contact with the 'Robles'. Farther south in the Peñuelas quadrangle, this limestone is present as massive beds near the top of the Pastillo Member of the Lago Garzas (KRUSHENSKY & MONROE, in press). Blocks of the *Crassostrea*-bearing limestone are also present in the slickenside-riddled 'Miramar' in the extreme eastern part of the Rio Descalabrado quadrangle. Rock mapped as 'Miramar' in the Rio Descalabrado and Coamo quadrangles (GLOVER, 1971, pl. 2; GLOVER & MATTSON, 1973) consists of a slickenside-riddled fault breccia developed, depending on location, from the Coamo Formation or from rocks lithologically indistinguishable from the Lago Garzas or the Maravillas Formations. Locally non-faulted rocks indistinguishable from the Maravillas and Lago Garzas Formations are also mapped as 'Miramar'.

Reconnaissance field study of the 'Miramar' in the southwest quarter of the Jayuya quadrangle (MATTSON, 1968b) where the unit lies chiefly between the Rio Prieto Formation of middle Eocene age (MATTSON, 1967, p. B27) and plutonic rocks of the Utuado batholith of Late Cretaceous and early Tertiary age (MATTSON, 1968b), indicates that the 'Miramar' is, as in other areas, a breccia, but in contrast to other areas it is there composed of hackly surfaced, sharply angular and unweathered clasts of plutonic rocks from the adjacent batholith which are suspended in a clayey, generally non-slickensided matrix. The breccia is cut by at least three discrete vertical shear zones, and in those zones slickensides are abundant in the clay matrix. Clasts of the granitic-textured plutonic rock are commonly only a few centimeters across, but blocks as much as 20 m across are revealed in roadcuts that cross the strike of the breccia. The 'Miramar Formation' mapped in the southwest quarter of the Jayuya quadrangle (MATTSON, 1968b) is unlike that in other areas; it is a fault breccia that postdates intrusion of the Utuado batholith and deposition of the Rio Prieto Formation. It is unrelated to gravity gliding.

The large quantity of clayey matrix, the extremely angular and commonly tabular or rhombohedral form of clasts, offsets along planar fractures noted in well-rounded clasts in

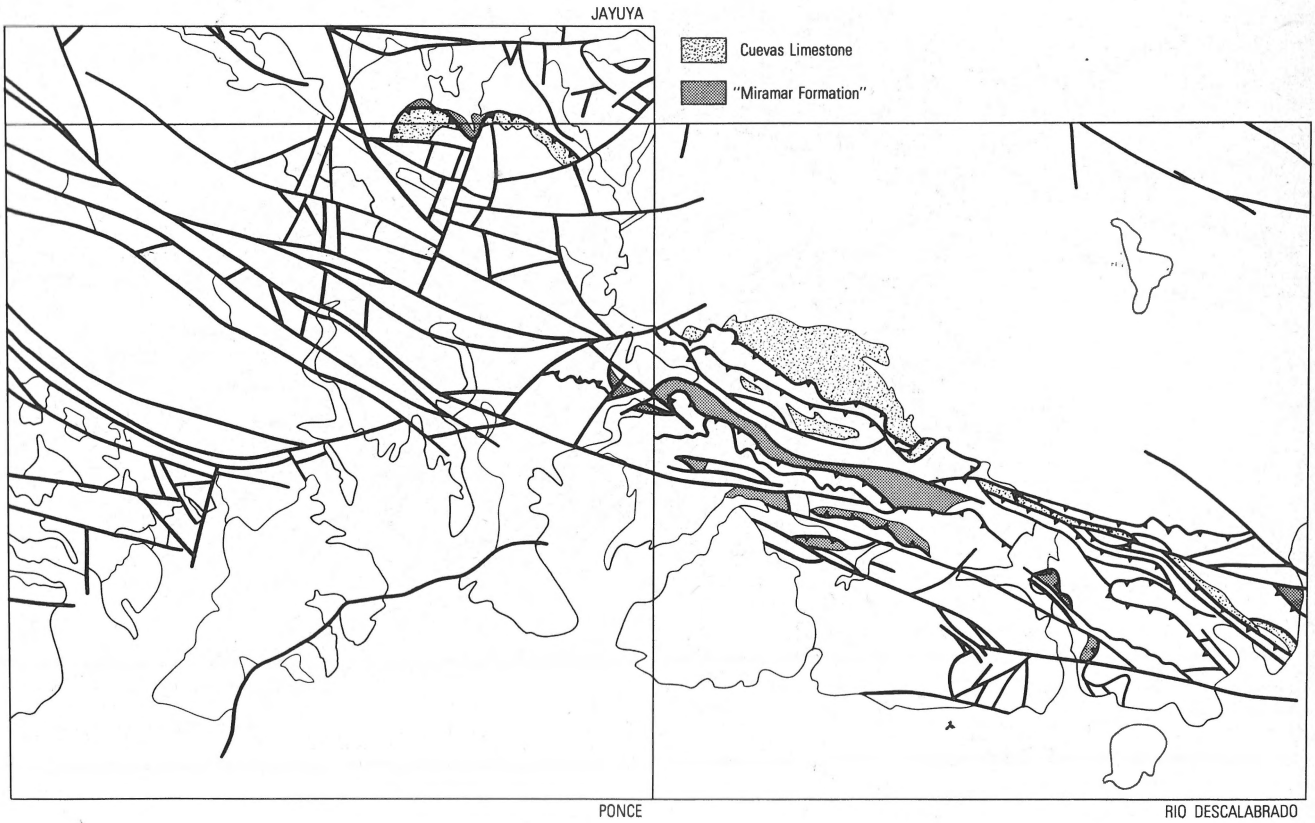

Fig. 2
Simplified geologic map showing the distribution of the Cuevas Limestone and the 'Mirimar Formation' in the Rio Descalabrado, Ponce, and Jayuya quadrangles.

the type area, the virtual lithologic identity of clasts with enclosing rock, both below and above the breccia in the Jayuya and Ponce quadrangles and part of the Río Descalabrado quadrangle, and the abundant slickensided surfaces on clasts and throughout much of the matrix of this breccia strongly suggest that the 'Miramar Formation' is, over wide areas, a fault breccia. Its wide association with gravity-glide plates in the Ponce, Río Descalabrado, and, as interpreted by the author, in the Jayuya quadrangles suggests that it may have been formed during and as a result of gravity gliding (KRUSHENSKY & MONROE, 1975).

Rock identified as 'Robles' (MATTSON, 1968a) in the Adjuntas quadrangle crops out as two northwest-striking bands separated by a generally fault-bounded band of Eocene volcaniclastic and intrusive rocks (MATTSON, 1968a). The southwest band of 'Robles' is intruded by Cretaceous and Tertiary stocks, and the northeast band is intruded by plutonic rocks of the Utuado batholith. Both bands of the 'Robles' are metamorphozed, and the original lithologic character of the rock has been largely obscured. Away from the intrusive rocks, however, the original rock is locally preserved, and it is evident that the rock is not Robles as originally defined.

The Robles Formation, as defined by PEASE & BRIGGS (1960) in the Comerio quadrangle in east-central Puerto Rico, consists chiefly of "thinly-bedded fine- to very fine-grained volcanic sandstone and siltstone intercalated with thickly-bedded, medium- to coarse-grained volcanic sandstone and waterlaid tuff". The Lapa Lava, Las Tetas Lava, and the Rio Maton Limestone are minor and areally restricted members of the Robles in and near the type area.

The 'Robles' as mapped in the northwest corner of the Adjuntas quadrangle and northwest of the village of Adjuntas is lithologically identical with, and in the northwest corner of the quadrangle in continuous outcrop with, a unit of dark-green to dark brownish-green polymict volcaniclastic breccia and minor lava mapped in the Monte Guilarte quadrangle (Krushensky & Curet, unpubl. data).

Lithic clasts that make up the breccia are composed of conspicuous large (1-3 cm long) and abundant (40 to 60 percent) clinopyroxene phenocrysts and smaller (0.2-0.5 cm long) generally inconspicuous dark-coloured plagioclase (labradorite-andesine) phenocrysts in a trachytic groundmass of microphenocrysts of plagioclase and clinopyroxene in a green chloritized and magnetite-speckled glass. Sorting of either clasts or matrix is lacking, and bedding is not apparent. Lava flows are rare, nonpillowed, and are mineralogically identical with the clinopyroxene-bearing lithic clasts in the

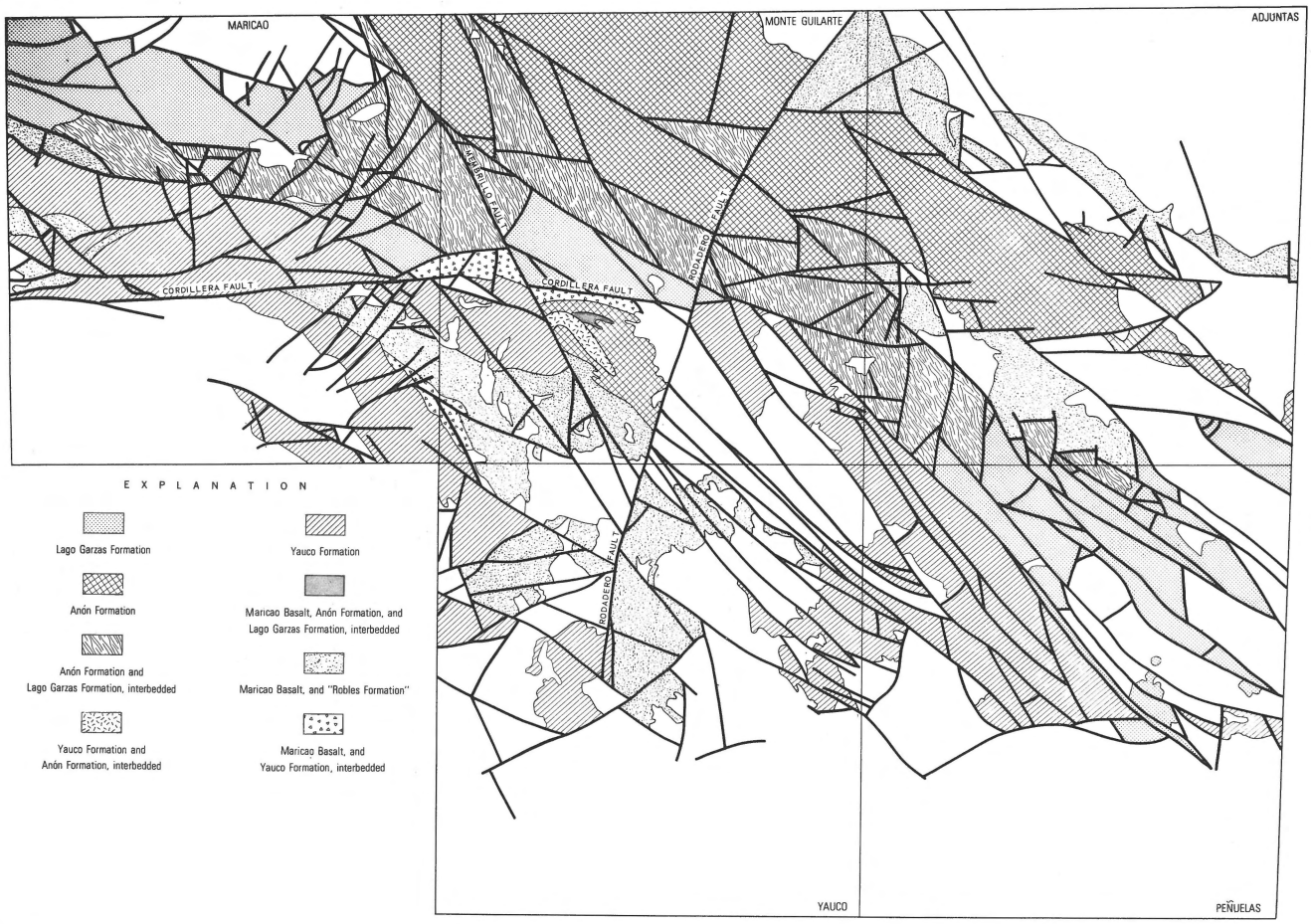

Fig. 3
Simplified geologic map showing the distribution of the Yauco. Anón. Maricao, and Lago Garzas Formations and areas where these formations are interbedded. Maricao Basalt in the Adjuntas quadrangle was originally mapped as the Robles Formation.

breccia facies. Although the unit is widely and deeply saprolitized, pseudomorphs of limonite after clinopyroxene phenocrysts are characteristic.

This distinctive lithofacies crops out widely over the southern half of the Monte Guilarte quadrangle, in the southeast part of the Maricao quadrangle, and south, east, and north of the village of Maricao in the Maricao quadrangle, where it was named the Maricao Basalt by MATTSON (1960, p. 337). Although Mattson suggested that the Maricao was composed principally of "lava and flow breccia with minor breccia and tuff", detailed mapping of the Mricao (MCINTYRE, 1975), Yauco (KRUSHENSKY & MONROE, 1977), and the Monte Guilarte (Krushensky & Curet, unpubl. data) quadrangles indicates that the Maricao is composed rather of massive volcaniclastic breccia and only sparse lava flows. The Maricao is lithologically identical with the 'Robles Formation' as mapped in the north and western parts of the Adjuntas quadrangle and in the Bayaney quadrangle (NELSON & TOBISCH, 1968), and is unlike the Robles of the type area. The Maricao Basalt is Campanian-Maastrichtian (MCINTYRE ET AL., 1970, p. D7) in age.

Distinctive lithofacies of the Yauco, Lago Garzas, and Maricao are now known to be interbedded in the Ponce (KRUSHENSKY & MONROE, 1975). Peñuelas (KRUSHENSKY & MONROE, in press), Yauco (KRUSHENSKY & MONROE, 1977), Maricao (Krushensky, unpubl. data), Mayaguez, and Rosario (Curet, unpubl. data) quadrangles. Lithofacies of Anón Formation, previously believed to be exclusively Tertiary in age (MATTSON, 1967, p. B31-32) are recognized as interbedded with the Yauco, Maricao, and Lago Garzas and 'Robles' in the Adjuntas, Monte Guilarte, Yauco, Maricao, and Bayaney (NELSON & TOBISCH, 1968) quadrangles.

Detailed mapping of the Monte Guilarte quadrangle and reconnaissance study of the adjoining Adjuntas and Maricao quadrangles indicate that interbedded lithofacies of the Lago Garzas and Anón Formations crop out from the type area of the Lago Garzas in the southwest corner of the Adjuntas quadrangle, across the Monte Guilarte quadrangle, and into the northeast half of the Maricao quadrangle. Lago Garzas where not interbedded with other lithofacies is mapped as the

Rio Blanco Formation in the Maricao quadrangle (MCINTYRE, 1975).

Dark-purple, dark-red, and dark-red-brown polymict volcaniclastic augite andesite breccia and nonpillowed lava flows characteristic of the Lago Garzas, locally with nonpillowed two-pyroxene-olivine basalt lava flows, are interbedded with pale-green, pale-brown, and pale-grey unsorted coarse polymict volcaniclastic hornblende dacite breccia and sparse nonpillowed lava flows and tuff characteristic of the Anón Formation, and crop out in a northwest-striking band across the Monte Guilarte quadrangle. In fault blocks in the northwest corner of the Monte Guilarte quadrangle, in the northeast corner of the Maricao quadrangle, and in the southwest corner of the Bayaney quadrangle, the polymict breccia component abruptly disappears. There the sequence consists of pale-green and pale-grey-green thinly- and well-bedded volcaniclastic siltstone and fine-grained sandstone and pillowed dark-red and purple augite-andesite lava flows and hyaloclastite breccia. The former sequence appears to have been deposited under subaerial conditions as mudflows and lava flows, whereas the latter sequence was deposited under submarine conditions. The siltstone-sandstone, pillowed lava, and hyaloclastite breccia sequence also includes local two-pyroxene-olivine pillowed lava flows. Mineralogically and chemically identical two-pyroxene-olivine flows are also known from the Pastillo Member of the Lago Garzas in the Yauco quadrangle (KRUSHENSKY & MONROE, 1977). MCINTYRE (1975) has mapped this marine facies of the interbedded Anón-Lago Garzas as the Mal Paso and Palma Escrita Formations in the northern half of the Maricao quadrangle. The Mal Paso includes, according to Pessagno (*in* MCINTYRE ET AL., 1970, p. B12), *Globoratalia* ss. spp. (keeled), *G. aragonensis* Nuttall, *G. densa* (Cushman), and *Globigerina* sp., which indicate a lower middle Eocene age for the enclosing Anón and Lago Garzas Formations. Pessagno (*in* MCINTYRE, 1974, p. D9) suggested that foraminifera collected from the stratigraphically underlying Palma Escrita Formation . . . "appear to be late Paleocene to Eocene in age".

Volcaniclastic breccia and sandstone with abundant and large clinopyroxene phenocrysts and clasts characteristic of the Maricao stratigraphically overlie and are interbedded with lithofacies characteristic of the Yauco and pale-gray, pale-green, and pale-brown polymict hornblende dacite breccia-conglomerate characteristic of the Anón Formation in a large fault block and four smaller fault blocks bounded by the Membrillo, Cordillera, and Rodadero faults in the south-central part of the Monte Guilarte quadrangle (Fig. 3) (Krushensky & Curet, unpubl. data). The Yauco lithofacies contains, according to Charles C. Smith (USGS, written commun., 1976) *Heterohelix* sp., *Globigerinelloides* sp., and *Globotruncana* cf. *G. elevata* (Brotzen), which indicate a middle Campanian to late Maastrichtian age for the Yauco, Anón, and Maricao Formations in the sequence.

SUMMARY

Recognition of the 'Miramar Formation' as a fault breccia in many areas of outcrop or, where not a fault breccia, as lithofacies equivalents of the Lago Garzas or Maravillas Formations, and recognition of the 'Robles Formation' as the Maricao in the Adjuntas quadrangle invalidates the bases upon which MATTSON (1966) conceived a major unconformity between Late Cretaceous and Eocene rocks in west-central Puerto Rico. In addition, recognition of the conformable interbedded nature of the Yauco, Lago Garzas, Maricao, 'Robles', and Anón lithofacies formerly thought to be restricted to either the Cretaceous or the Eocene unequivocally indicates the continuity of deposition from the Late Cretaceous to at least the middle Eocene. The concept of an unconformity between Late Cretaceous and Eocene rocks in west-central Puerto Rico is therefore rejected.

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