The Lares Limestone and Montebello Member of the Cibao Formation along Highway PR10

Field Trip Guide Figures

by

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Figure 1A: Mapa Geológico de Puerto Rico

Renken et al., 2002
Figure 1B: Stratigraphic nomenclature and ages for Oligocene, Miocene, and Pliocene sedimentary rocks of the North Coast Tertiary Basin.

Renken et al., 2002
Figure 1C

<table>
<thead>
<tr>
<th>AGE</th>
<th>This report (subsurface)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLIOCENE</td>
<td></td>
</tr>
<tr>
<td>LATE</td>
<td>Quebradillas Limestone</td>
</tr>
<tr>
<td>MIDDLE</td>
<td>Aymamón Limestone</td>
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<tr>
<td></td>
<td>Aguada (Los Puertos) Limestone</td>
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<tr>
<td>EARLY</td>
<td>Undifferentiated Cibao Formation</td>
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<tr>
<td></td>
<td>Montebello Limestone Member</td>
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<tr>
<td></td>
<td>Mudstone unit</td>
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<tr>
<td></td>
<td>Quebrada Arenas and Rio Indio Limestone Members</td>
</tr>
<tr>
<td>LATE</td>
<td>Lares Limestone</td>
</tr>
<tr>
<td>OLIGOCENE</td>
<td>San Sebastián Formation</td>
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</table>

"MIDDLE"

Renken et al., 2002

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Strontium Isotope Stratigraphy for Oligocene-Miocene Carbonate Systems in Puerto Rico and the Dominican Republic: Implications for Caribbean Processes Affecting Depositional History

Diana Ortega-Ariz,¹,², x Evan K. Franseen,¹,² Hernán Santos-Mercado,³ Wilson R. Ramirez-Martinez,³ and Elson E. Core-Suárez³

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My | Series | Chron (C) | Aged | Northern (N) PR (Ward et al., 2002) | N PR (This study) |
---|--------|-----------|------|------------------------------------|-------------------|
5  | PLIOCENE | 5.3 | Quebradillas Formation |
7.2 | Messinian | C2A | |
11.6 | Tortonian | C3 | |
13.8 | Serravalian | C3A | |
16.0 | Langhian | C3 | |
20.4 | Burdigalian | C3 | |
23.0 | Aquitanian | C4 | |
24.10 | Montebello Member |
26.51 | Lares LS |
27.30 | Montebello Mbr |
29.78 | San Sebastian Fm |
30  | Oligocene | 28.4 | San Sebastián Formation |

Figure 2: Thickness of Lares Limestone, northern Puerto Rico (outcrop extent modified from Monroe, 1980).

Renken et al., 2002
Figure 3: Thickness of Montebello Limestone, northern Puerto Rico (outcrop extent modified from Monroe, 1980).

Renken et al., 2002
Figure 4: East-west geologic cross section of northern Puerto Rico (from Rodríguez-Martínez, 1995).
Figure 4: East-west geologic cross section of northern Puerto Rico (from Rodríguez-Martínez, 1995).

EXPLANATION

- Alluvial valley aquifer
- Local confining unit
- Unsaturated (nonaquifer)
- North Coast Limestone aquifer system
  - Upper aquifer
  - Confining unit
  - Lower aquifer
  - Basal confining unit

Geology modified from: Rodríguez-Martínez, 1995


Fig. 5: The base of the Lares Limestone and its contact with the San Sebastián Formation exposed at the intersection of the Highways PR 10 and PR 6621.
Fig. 6: The base of the Lares Limestone and its contact with the San Sebastián Formation exposed at the PR10-PR6621 intersection (N18°18’52'', W66°41’05’’).
Fig. 7: Close-up of the Lares Limestone-San Sebastián Formation contact exposed at the PR10-PR6621 intersection. Here the San Sebastián Formation consists of conglomerate, composed of particles ranging from pebbles to cobbles.
Fig. 8: The base of the Lares Limestone and its contact with the San Sebastián Formation exposed at the PR10-PR6621 intersection. Lines of cobbles composed of weathered (oxidized) volcanic rocks follow the apparent dip of the strata.
Fig. 9: An oyster layer at the base of the Montebello Member, mapped by Monroe (1980a), helped to define the Lares Limestone-Montebello Member contact. The oyster layer is readily identifiable throughout the field area.
Fig. 10. The top of the Montebello Member at PR 10 was mapped by Ramirez-Martinez (2000) at an erosional surface located at N 18°23'33", W 66°41'42", in front of the first scenic overlook from Arecibo to Utuado.
Fig. 10. The top of the Montebello Member at PR10 was mapped by Ramirez-Martinez (2000) at an erosional surface located at N 18°23'33", W 66°41'42", in front of the first scenic overlook from Arecibo to Utuado.
Fig. 11: The presence of freshwater gastropods and erosional surfaces, suggest subaerial exposure at about 305 meters from the base of the Montebello Member. They were used to establish the upper limit of the Montebello Member at the PR10 Highway section.
Fig. 12: Gastropods identified as belonging to the genera Pomacea and Physa (Galluzzo, personal communication, 1998) present above an erosional surface located at about 295 meters from the base of Montebello Member section on PR 10. Both genera are freshwater taxa with no tolerance for salinity and are very common in freshwater units of Tertiary age throughout the Caribbean (Vokes, personal communication, 1998).

Physa sp.

Pomacea sp.
Fig. 13: Vertical cylindrical structures just below the bed where freshwater gastropods are present appear to be rhizoliths.
Fig. 14: Large-scale cavities filled with fine carbonaceous mud and carbonate breccias are present below the bed with freshwater gastropods. They are probably Tertiary solution collapse features.
<table>
<thead>
<tr>
<th>SERIES</th>
<th>STRATIGRAPHIC UNITS</th>
<th>SEQUENCE BOUNDARY</th>
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<tr>
<td>OLIGOCENE</td>
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<td>&quot;MIDDLE&quot;</td>
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Fig. 15:
-Sequence-stratigraphic framework of the Oligocene to middle Miocene sedimentary rocks of the North Coast Tertiary Basin, Puerto Rico. From Renken et al., 2002.
Fig. 16: San Sebastián Formation - Lares Limestone contact at PR10 (N18°18′52″, W66°41′05″)
Fig. 18: Oyster Layer at PR10 (N18°01'58", W66°04'51")
Fig. 19: Oyster layer, at the basal Montebello Member at PR 10.
Fig. 21: Montebello Member – Jobos Formation Contact. Highway PR10 and road PR621 Intersection.

(N18°19′58″, W66°40′42″)
Fig. 22: A 0.5 meter thick grainstone bed interpreted as a submarine hardground.
Fig. 23: A highly undulatory bed composed of carbonaceous clays is present in between the fossiliferous limestones.
Fig. 24: The red arrow points to a layer that could mark the position of the air-water interface (water table) present in the area at some moment in time. The blue arrow points to a grainstone surface with a high abundance of Kuphus fossils in growth position. N 18°22'17", W 66°41'39"
Fig 25: Grainstone layer with abundant *Kuphus incrassatus*; Stop #10
Fig. 26: The presence of freshwater gastropods and erosional surfaces, suggest subaerial exposure at about 305 meters from the base of the Montebello Member. They were used to establish the upper limit of the Montebello Member at the PR10 Highway section.