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

Field Trip Guide Figures

by

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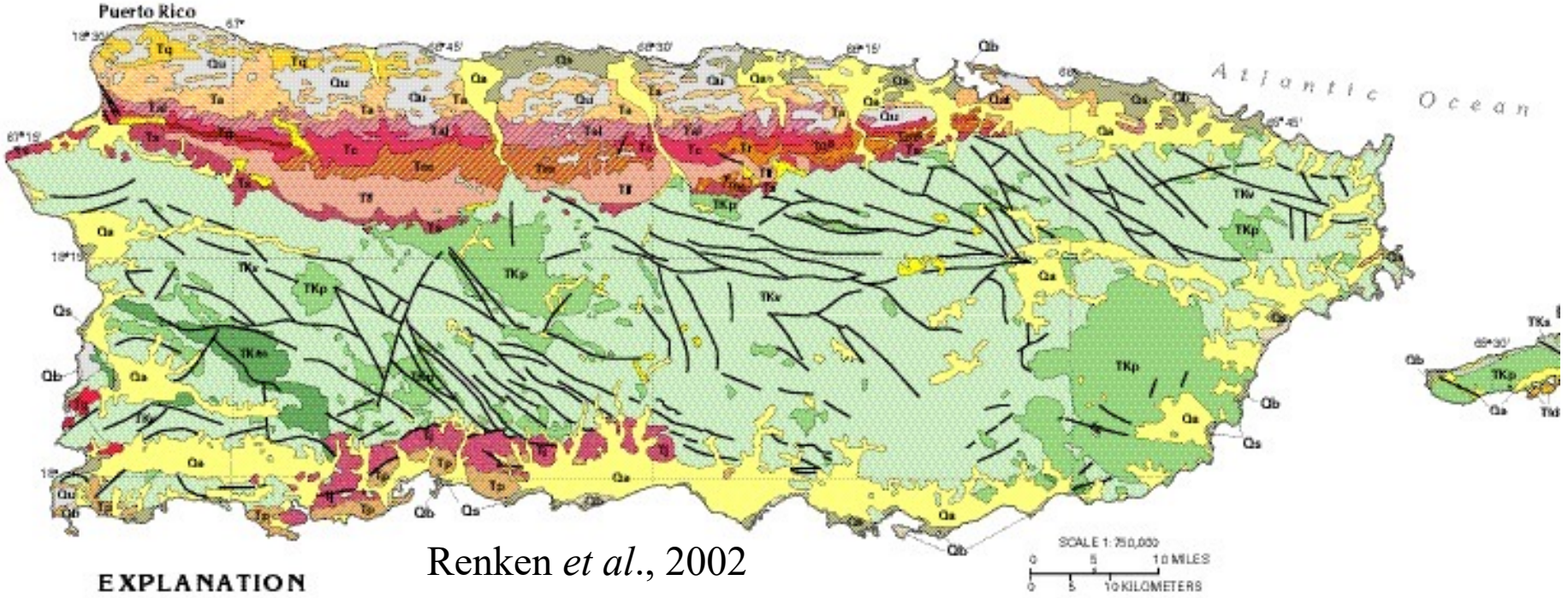
Figure 1A: Mapa Geológico de Puerto Rico



Renken *et al*., 2002

EXPLANATION

Quaternary deposits

- Qa — Alluvium
- Ql — Landslide deposits
- Qb — Beach deposits
- Qs — Swamp and marsh deposits
- Qaf — Artificial fill
- Qu — Undifferentiated surficial deposits

Pliocene and Miocene rocks

- Tq — Quebradillas Limestone
- Tp — Ponce Limestone

Miocene rocks

- Ta — Aymamón Limestone
- Tal — Aguada (Los Puertos) Limestone
- Tg — Guanajibo Formation
- Tc — Cibao Formation
- Tms — Montebello Limestone Member
- Tqa — Quebrada Arenas Limestone Member—Includes Miranda Sand Member
- Tr — Río Indio Limestone Member—Includes Almirante Sur Lentil
- Tsg — Guajataca Member

Miocene and Oligocene deposits

- Tmas — Mucarabones Sand
- Tj — Juana Díaz Formation
- Tl — Lares Formation
- Ts — San Sebastián Formation

Eocene, Paleocene, and Cretaceous rocks

- TKv — Volcanic and sedimentary rocks
- TKp — Plutonic rocks—Mostly quartz diorite and granodiorite
- TKm — Metamorphic (serpentinite), sedimentary, and igneous rocks

Fault

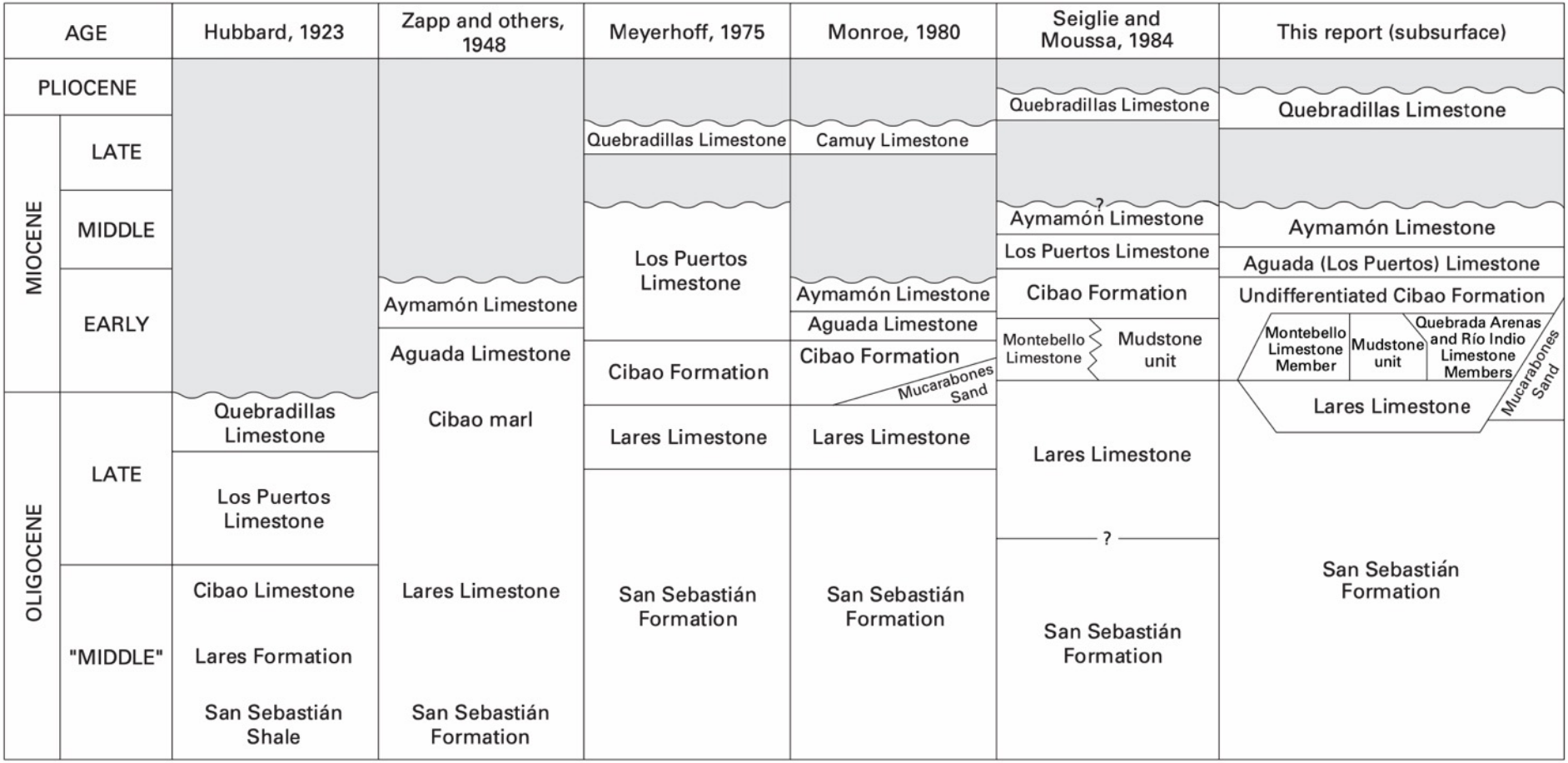
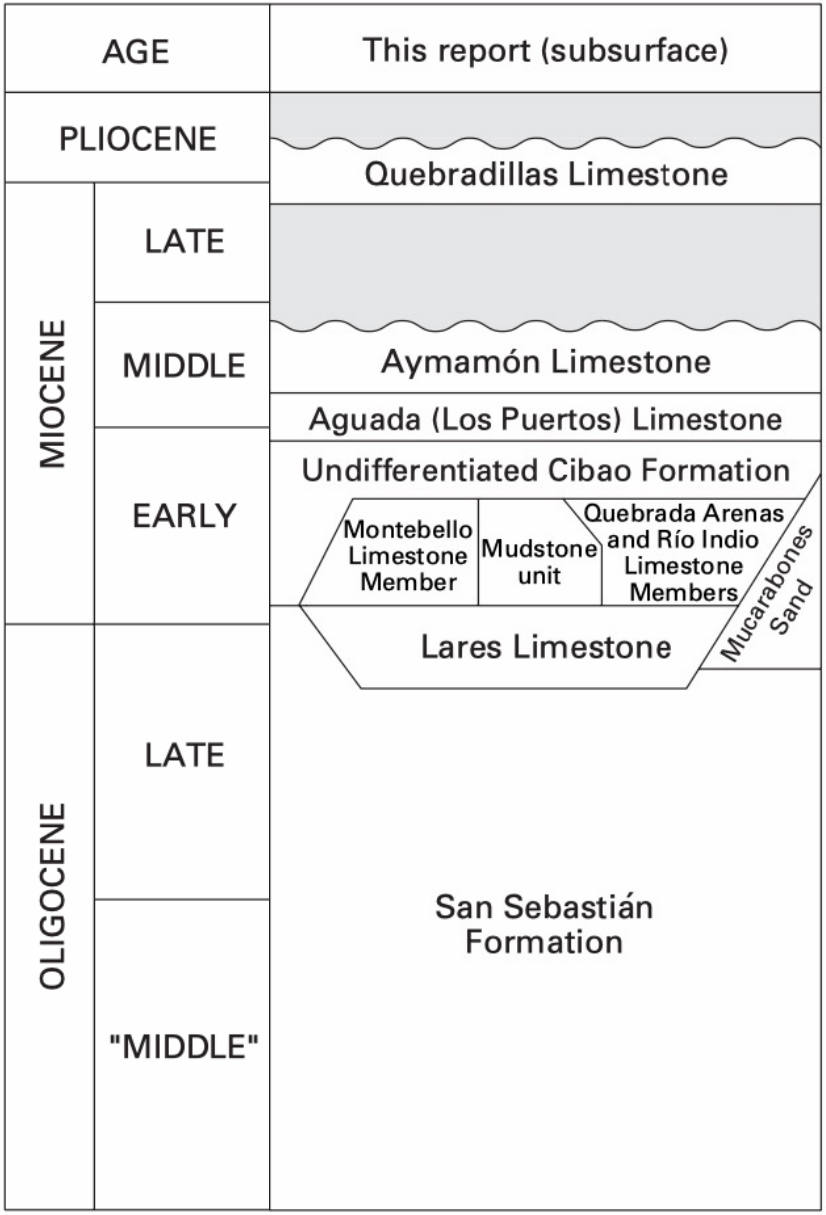


Figure 1B: atigraphic nomenclature and ages for Oligocene, Miocene, and Pliocene sedimentary rocks of the North Coast Tertiary Basin.

Renken et al., 2002

Figure 1C

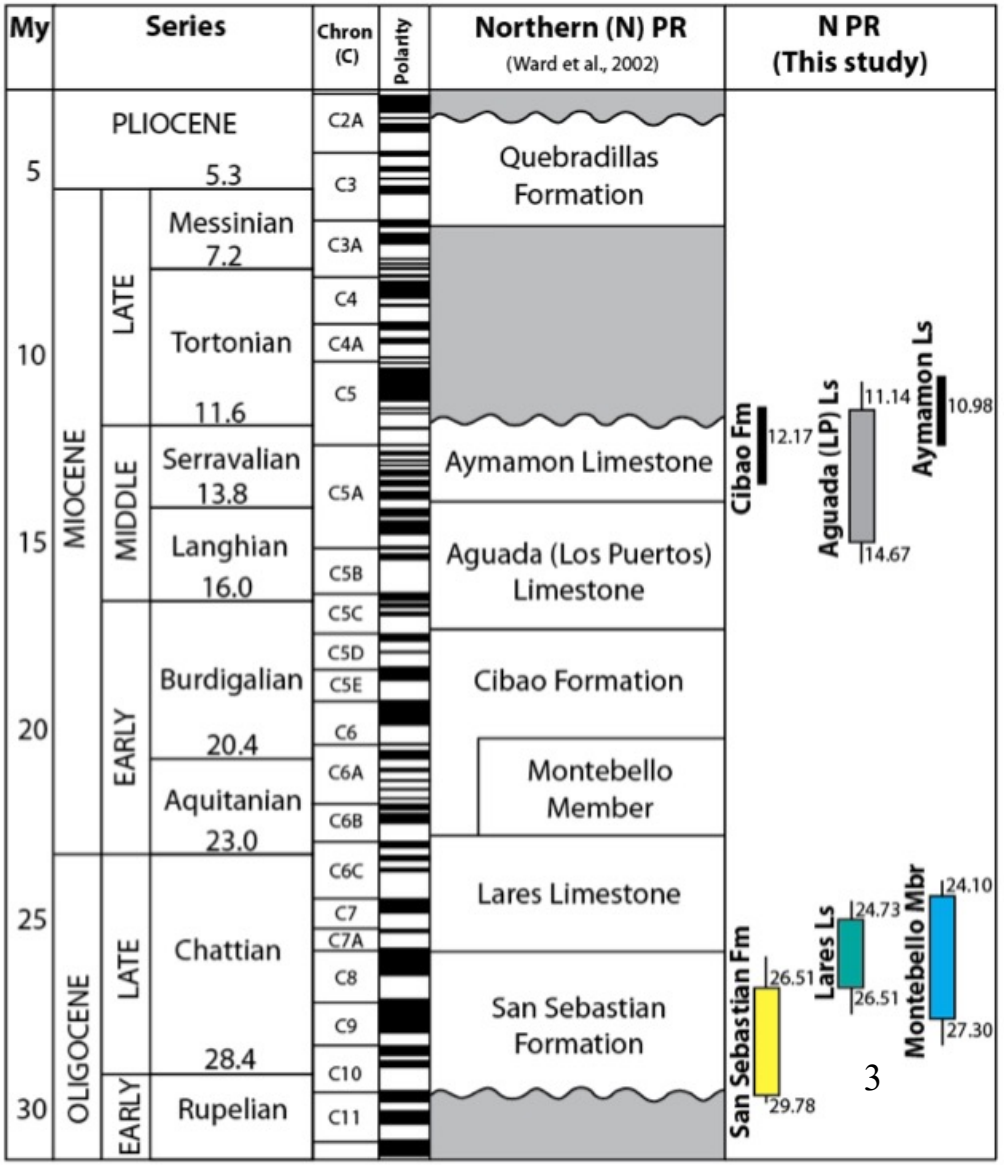


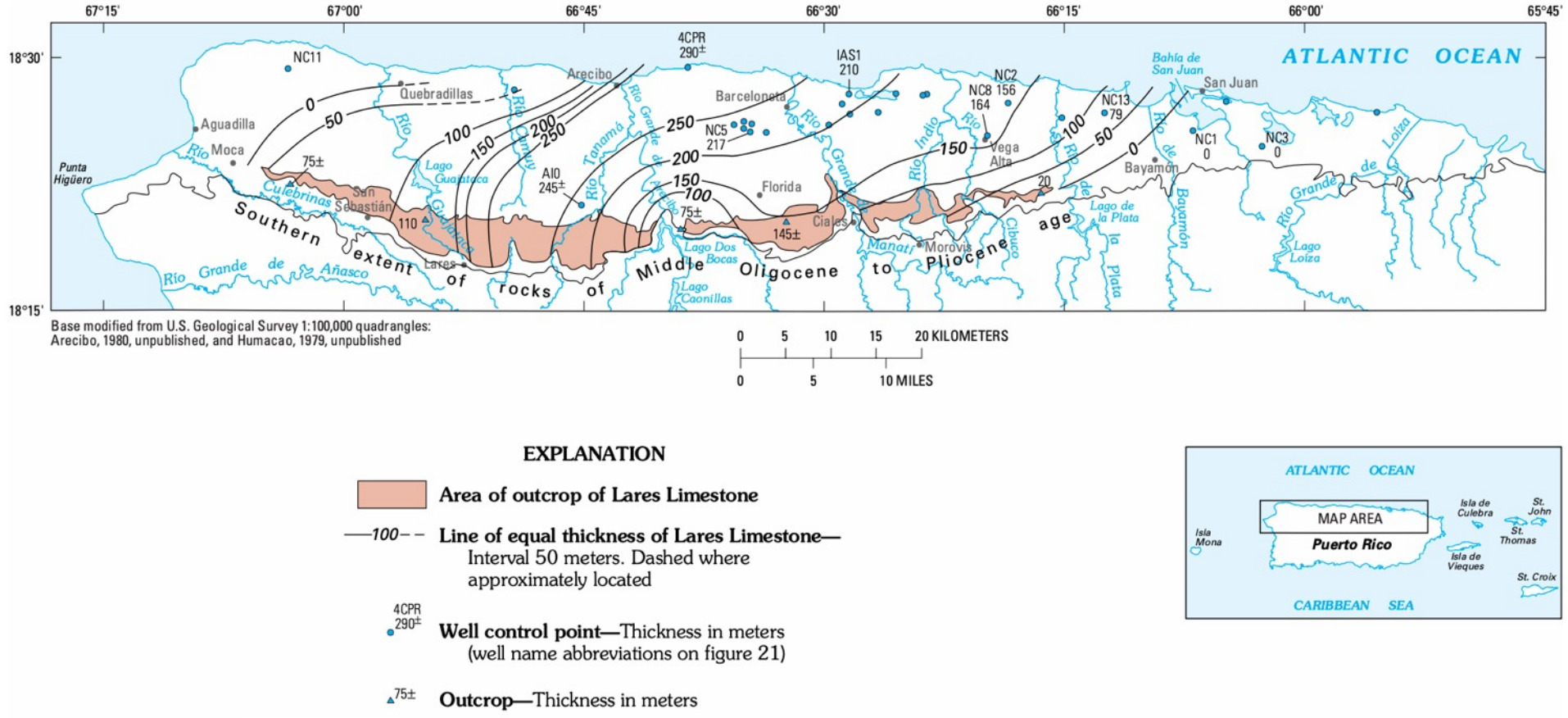
Renken et al., 2002

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

2015

Diana Ortega-Ariza,[1,2,] Evan K. Franseen,[1,2] Hernán Santos-Mercado,[3] Wilson R. Ramírez-Martínez,[3] and Elson E. Core-Suárez[3]*





EXPLANATION

Area of outcrop of Lares Limestone

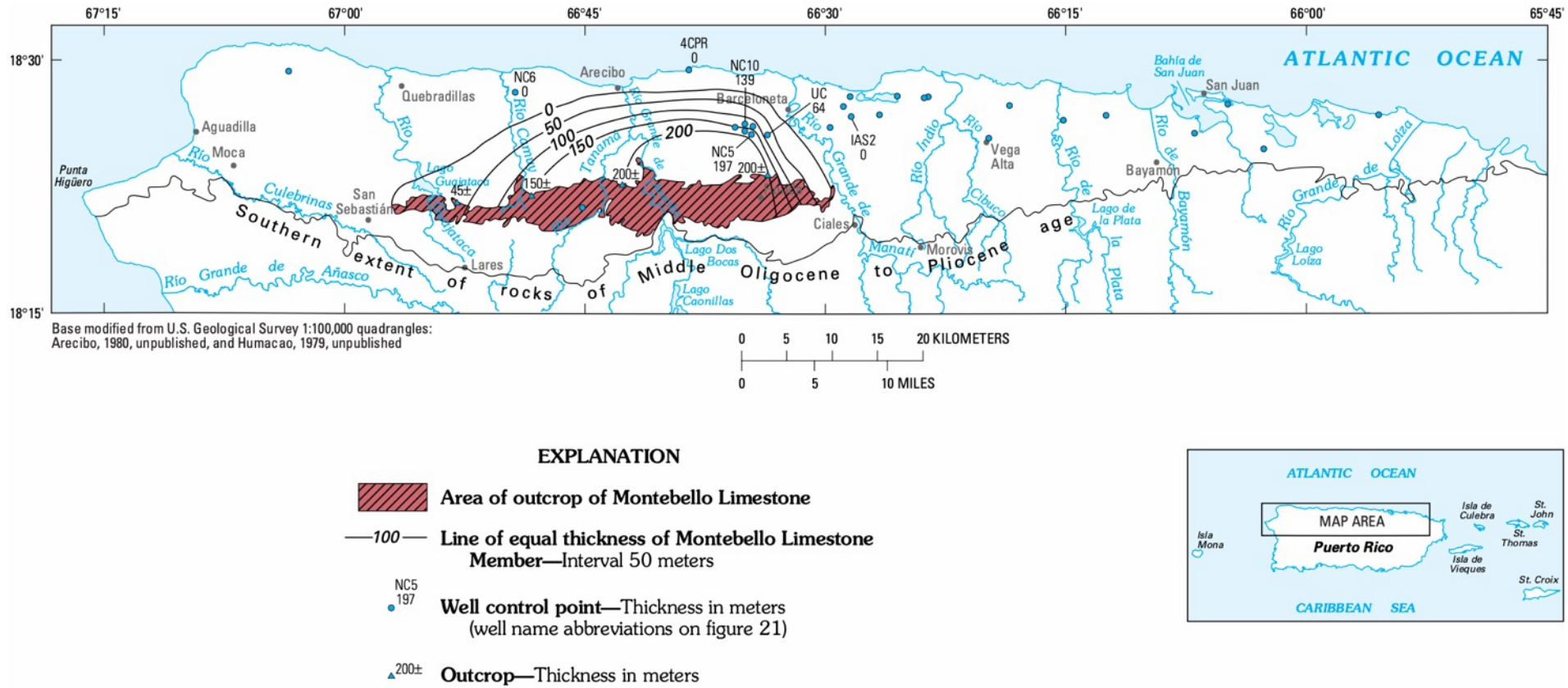
—100— **Line of equal thickness of Lares Limestone—** Interval 50 meters. Dashed where approximately located

4CPR 290± **Well control point—**Thickness in meters (well name abbreviations on figure 21)

75± **Outcrop—**Thickness in meters

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

Renken et al., 2002



EXPLANATION

Area of outcrop of Montebello Limestone

—100— **Line of equal thickness of Montebello Limestone Member**—Interval 50 meters

NC5 197 **Well control point**—Thickness in meters (well name abbreviations on figure 21)

200± **Outcrop**—Thickness in meters

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

Renken et al., 2002

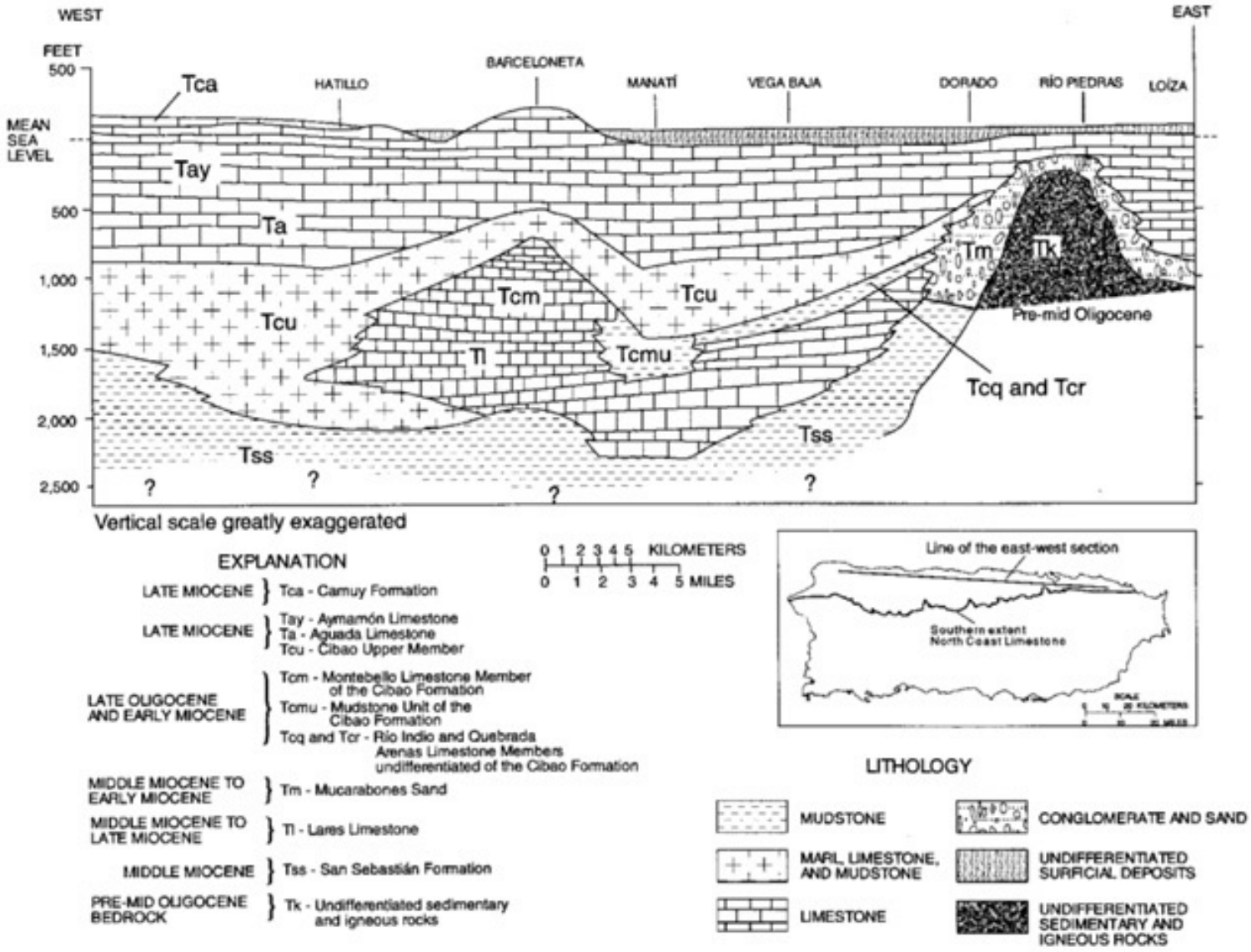


Figure 4: East-west geologic cross section of northern Puerto Rico (from Rodríguez-Martínez, 1995).

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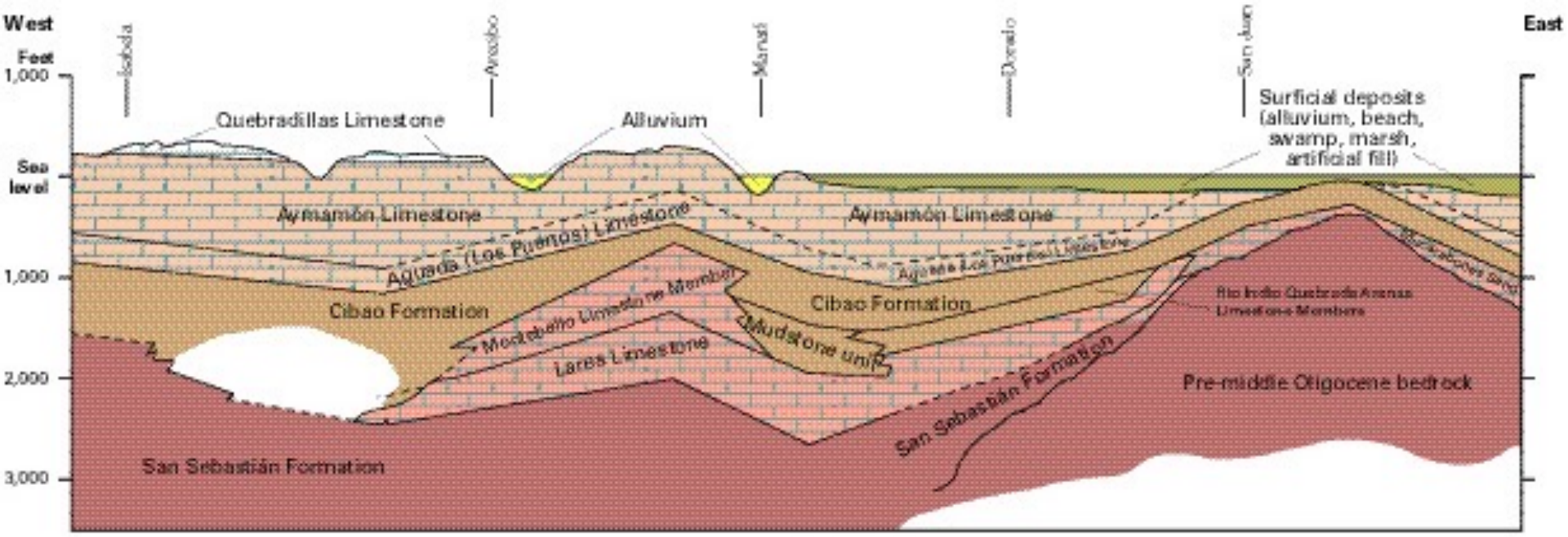


Geology modified from: Rodríguez-Martínez, 1995

EXPLANATION

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

Ward, W.C., Scharlach, R.A., and Hartley, J.R., 1991, Controls on porosity and permeability in subsurface Tertiary carbonate rocks of northern Puerto Rico, in Gómez-Gómez, Fernando, Quiñones-Aponte, Vincente, and Johnson, A.I., eds., Regional aquifer systems of the United States—Aquifers of the Caribbean Islands: American Water Resources Association Monograph 15, p. 17–23;

Ward, W.C., Scharlach, R.A., and Hartley, J.R., in press, Geology of the North Coast ground-water province of Puerto Rico, in Renken, R.A., Ward, W.C., Gill, I.P., Rodríguez-Martínez, Jesús, and Gómez-Gómez, Fernando, Geology and hydrogeology of the Caribbean Islands aquifer system of Puerto Rico and the U.S. Virgin Islands: U.S. Geological Survey professional Paper 1419.

Hydrogeology modified from Renken, R.A., and Gómez-

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

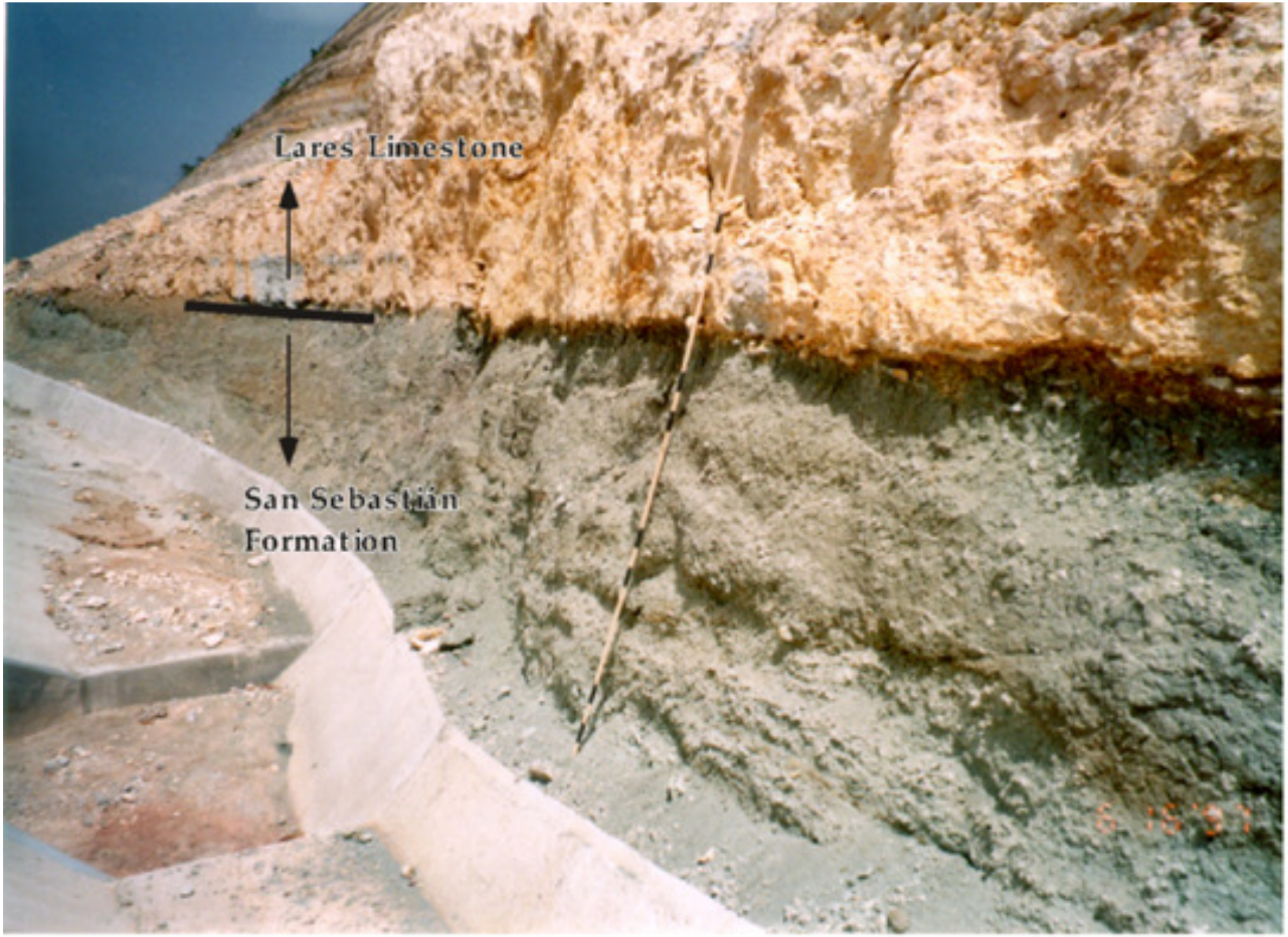


Fig. 6: The base of the Lares Limestone and its contact with the San Sebastián Formation exposed at the PR10-PR6621 intersection (N18°18'52", W66°41'05").

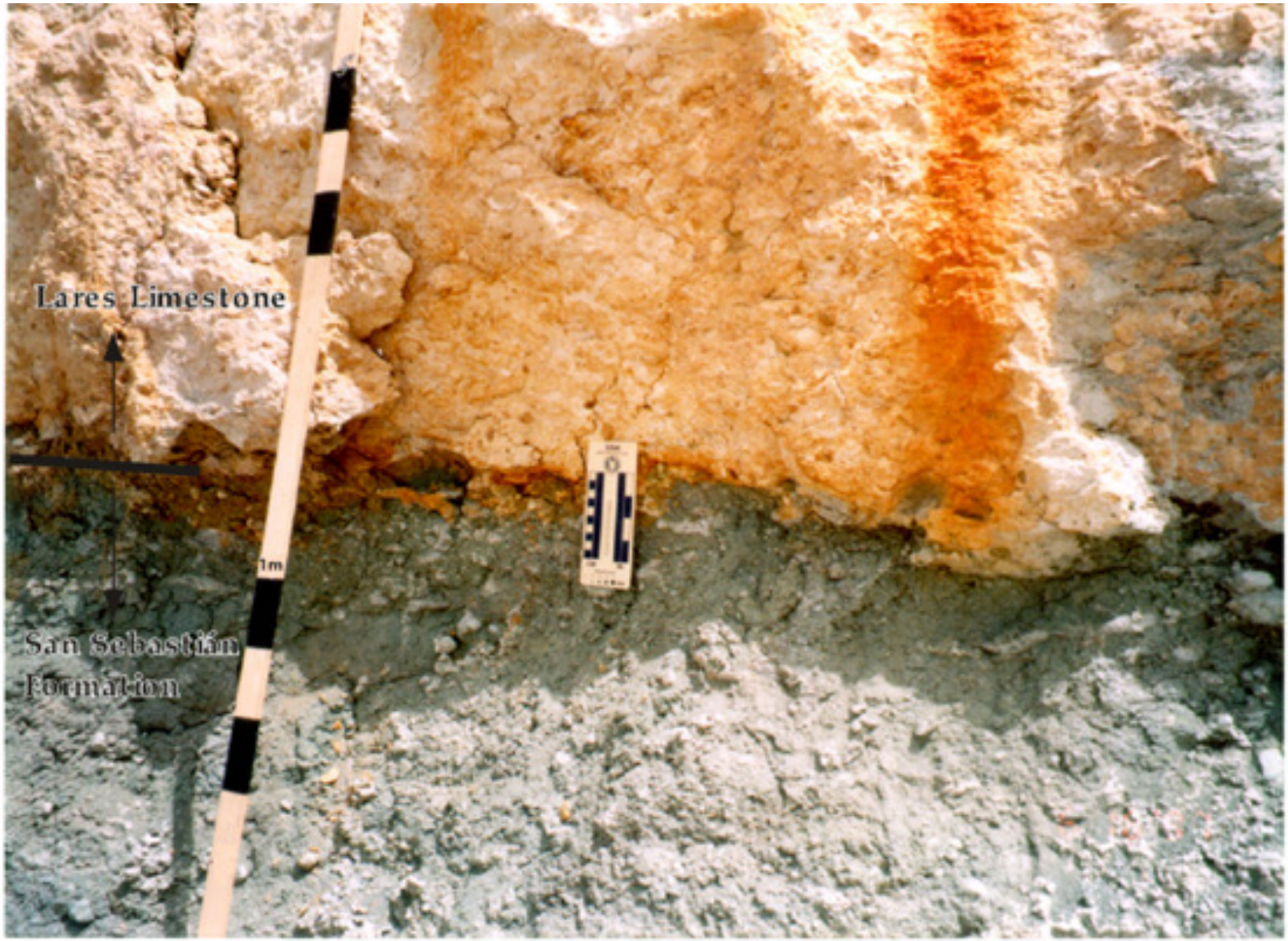


Fig. 7: Close-up of the of the Lares Limestone-San Sebastián Formation contact exposed at the PR10-PR6621 intersection. Here the San Sebastián Formation consists of conglomerate, composed of particles ranging from pebbles to cobbles.

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.

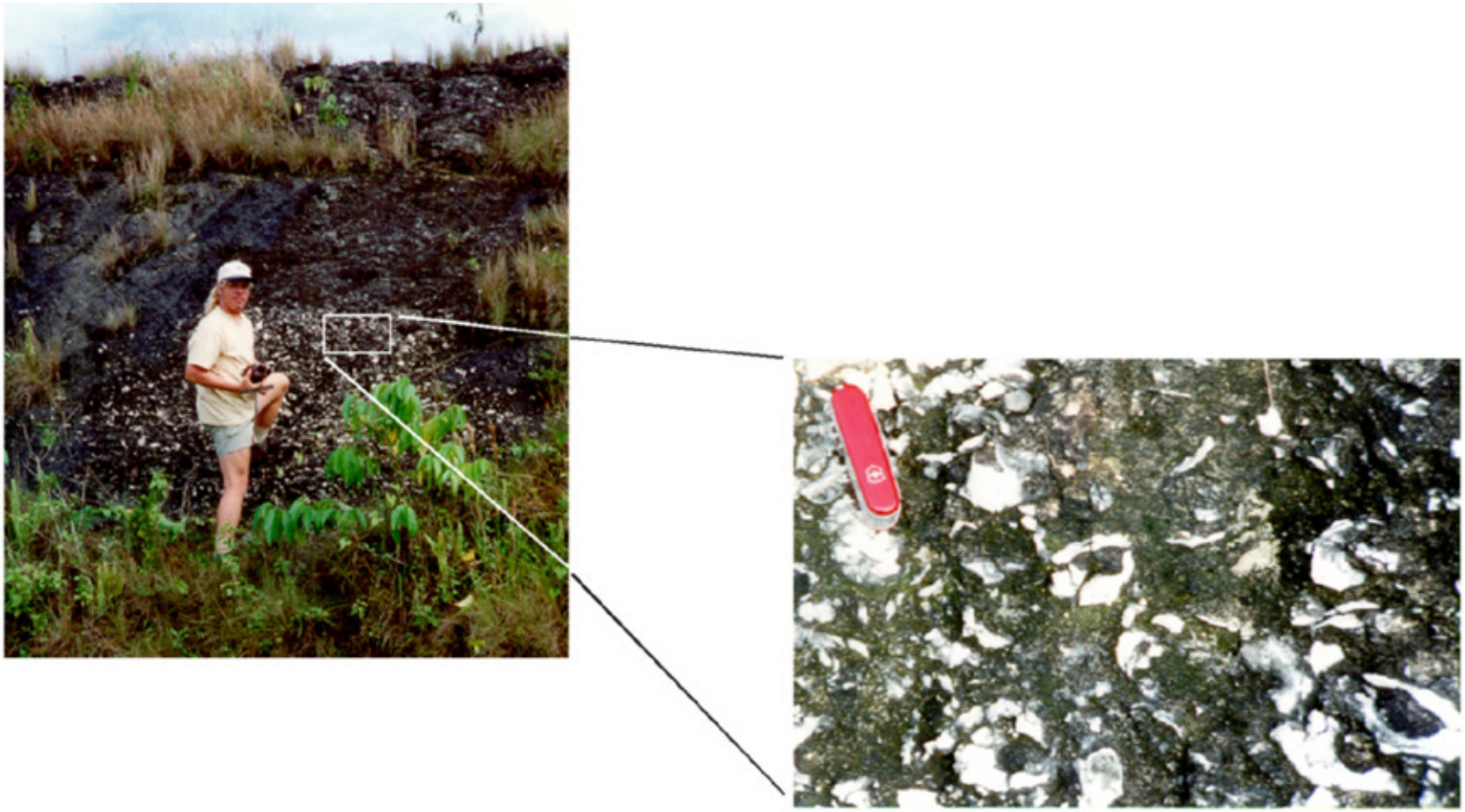
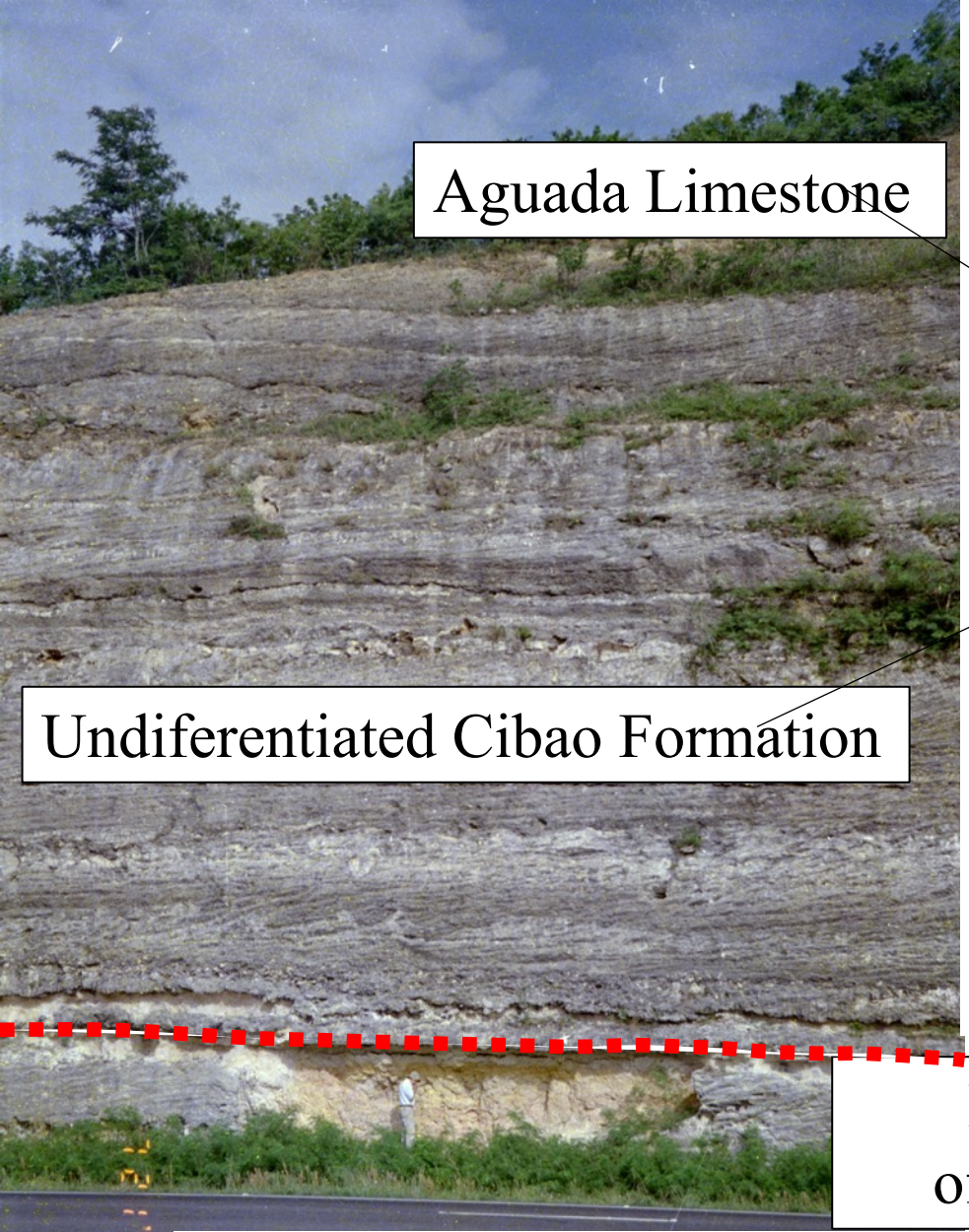


Fig. 9: An oyster layer at the base of the Montebello Member, mapped by Monroe (1980a), helped to define the Lares Limestone-Montebello Member contact. The oyster layer is readilly identifiable throughout the field area.

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.



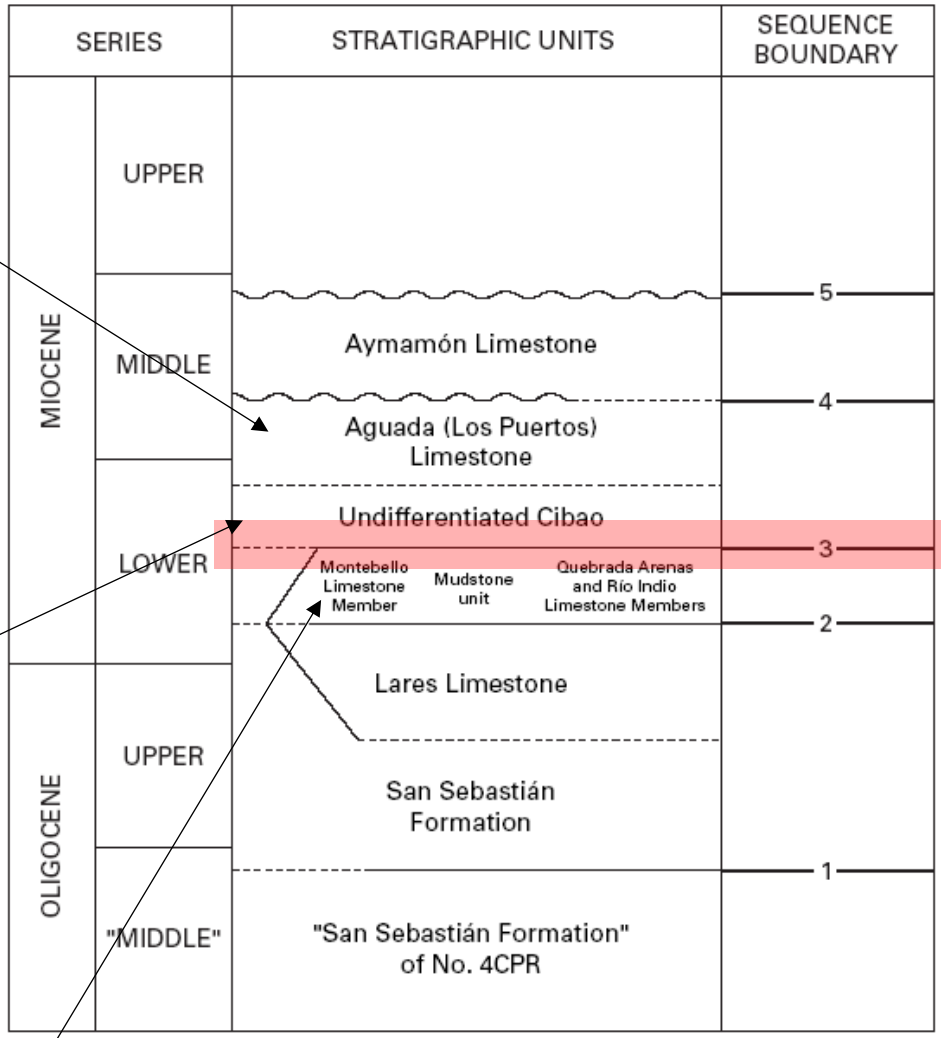


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Fig. 11: The presence of freshwater gastropods and erosional surfaces, suggest subaerial exposure at about 305 meters from the base of the Montebello Member. They were used to establish the upper limit of the Montebello Member at the PR10 Highway section.

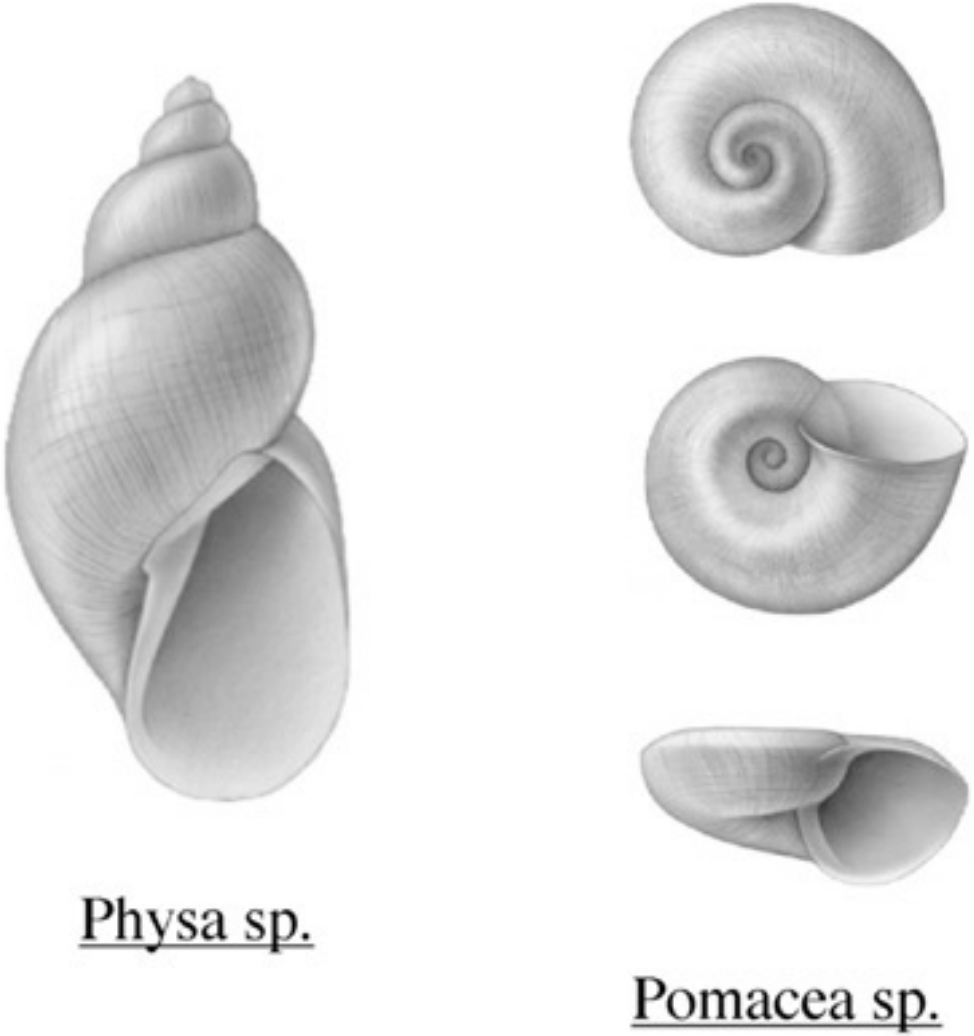


Fig. 12: Gastropods identified as belonging to the genera Pomacea and Physa (Galluzzo, personal communication, 1998) present above an erosional surface located at about 295 meters from the base of Montebello Member section on PR10. Both genera are freshwater taxa with no tolerance for salinity and are very common in freshwater units of Tertiary age throughout the Caribbean (Vokes, personal communication, 1998).

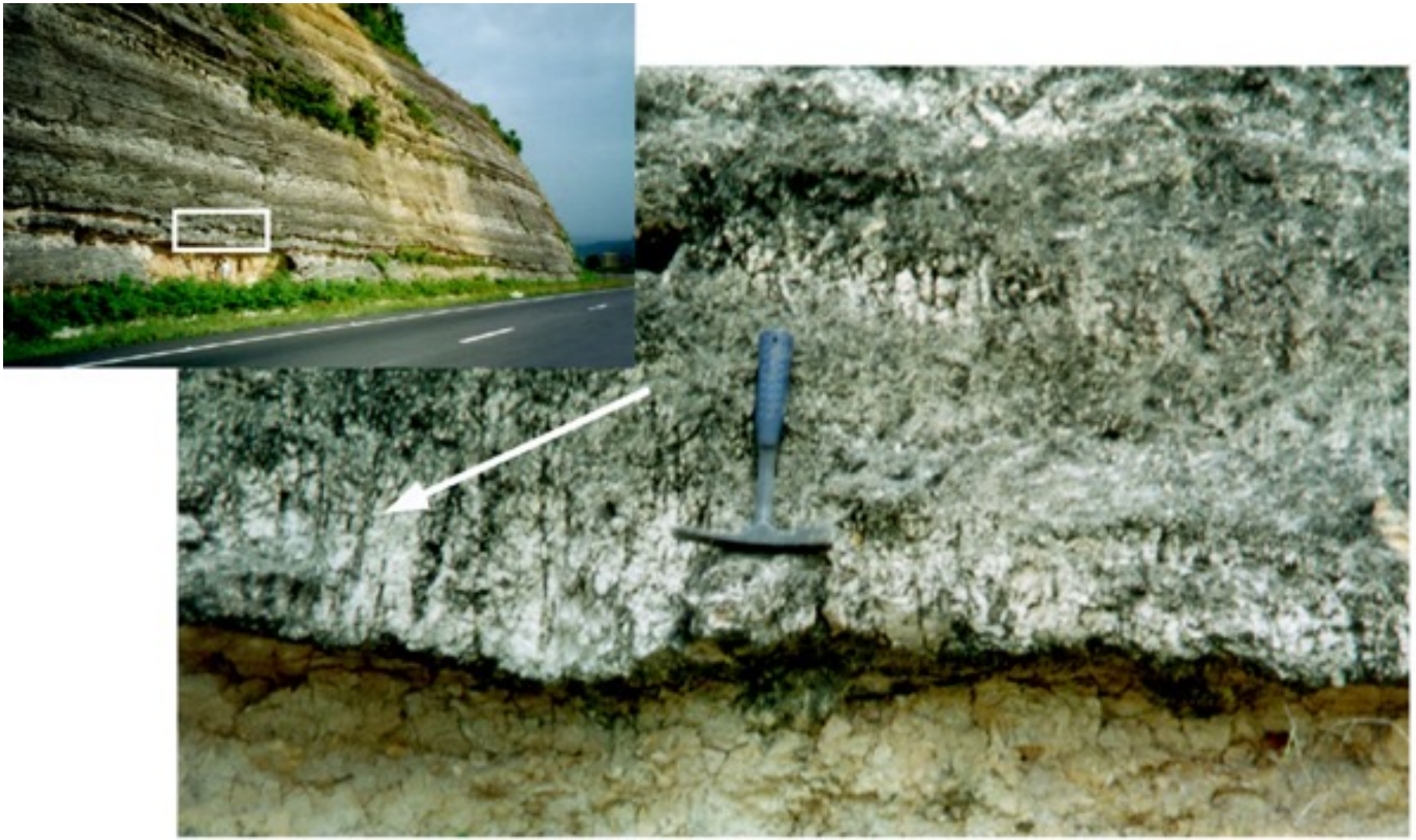


Fig. 13: Vertical cylindrical structures just below the bed where freshwater gastropods are present appear to be rhizoliths.

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.

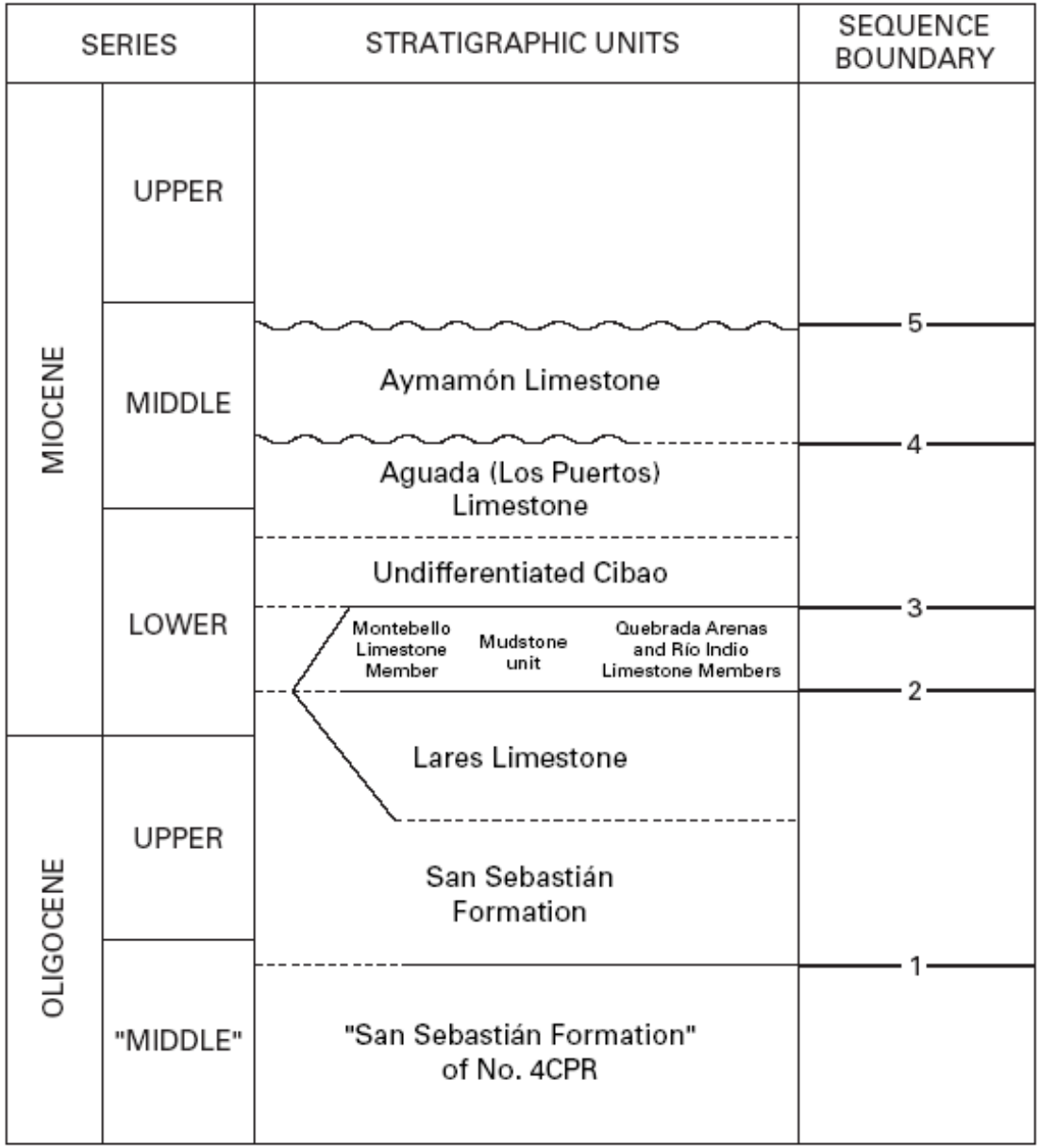


Fig. 15:
-Sequence-stratigraphic framework of the Oligocene to middle Miocene sedimentary rocks of the North Coast Tertiary Basin, Puerto Rico. From Renken et al., 2002.

Fig. 16: San Sebastián Formation - Lares Limestone contact at PR10 (N18o18'52", W66o41'05")

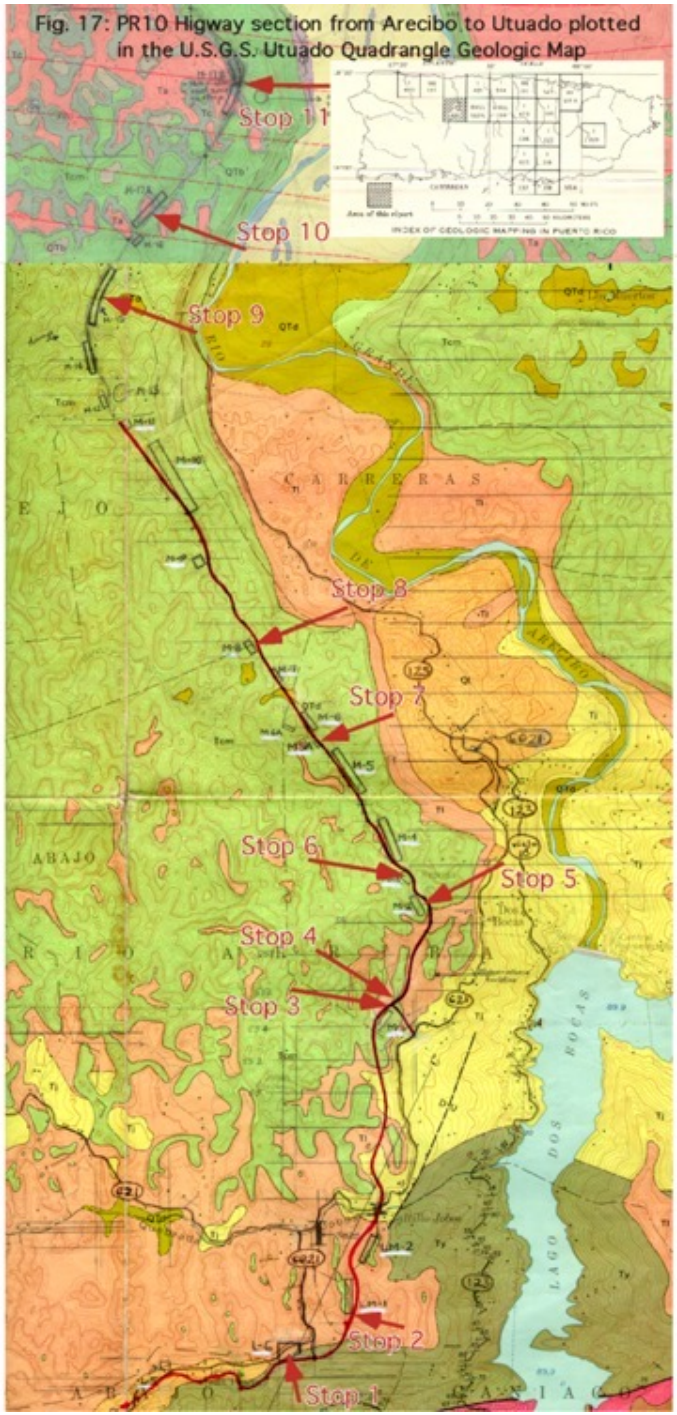


Fig. 17: PR10 Higway section from Arecibo to Utuado plotted in the U.S.G.S. Utuado Quadrangle Geologic Map
Stop 11
Stop 10
Stop 9
Stop 8
Stop 7
Stop 6
Stop 5
Stop 4
Stop 3
Stop 2
Stop 1
CARRERAS
ABAJO
LAGO DOS BOCAS

Figure 17:

Fig. 18: Oyster Layer at PR10 (N18018'58", W66040'51")

Fig. 19: Oyster layer, at the basal Montebello Member at PR 10.

Fig. 20: Montebello Member - Jobos Formation Contact

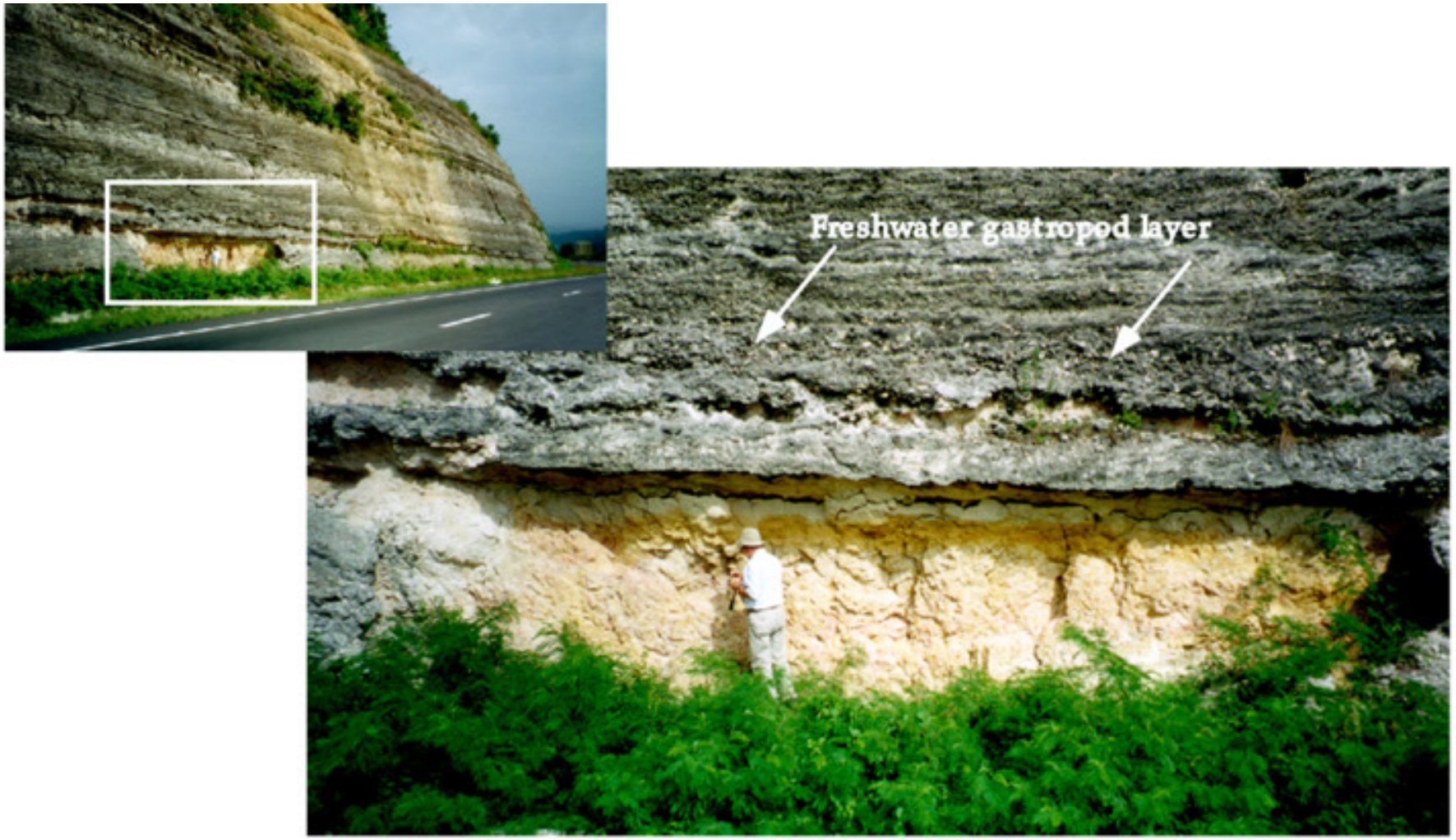

Fig. 21: Montebello Member – Jobos Formation Contact.
Highway PR10 and road PR621 Intersection.
(N18°19'58", W66°40'42")

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 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 18o22'17", W 66o41'39"

Fig 25: Grainstone layer with abundant Kuphus incrassatus; Stop #10



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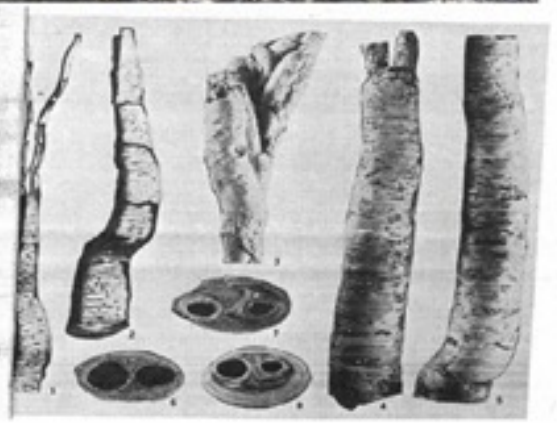

Fig 27: Kuphus incrassatus