Montheil, L., Philippon, M., Cornée, J.-J., BouDagher-Fadel, M., van Hinsbergen, D.J.J., Camps, P., Maffione, M., Audemard, F., Brons, B., Van der Looij, K.J.R., and Münch, P., 2022, Geological architecture and history of the Antigua volcano and carbonate platform: Was there an Oligo–Miocene lull in Lesser Antilles arc magmatism?: GSA Bulletin, https://doi.org/10.1130/B36465.1.

Supplemental Material

Supplemental Material 1. Description of the sections, ages and depositional settings.

Supplemental Material 2. Microfacies and larger benthic foraminifera content.

Supplemental Material 3. Description of the seismic profiles 508 and 510.

Supplemental Material 4. Structural measurements collected in the field. Strikes are expressed from 0 to 360° following the right hand rule.

Supplemental Material 5. Detail of Ar/Ar step-heating analyses.

APPENDIX 1

DESCRIPTION OF THE SECTIONS, AGES AND DEPOSITIONAL SETTINGS

Central Plain Group (CPG)

The CPG was investigated into two sections. The Corbison section (Fig.2, Appendix 1.1) comprises 29 m- thick green silty clays with m- thick interbeddings of silicified lacustrine limestones and tuffites, tuffaceous microbreccia, volcaniclastic sandstones and volcaniclastic debris flows with cm- sized andesite debris. The silicified beds yielded well-preserved shells belonging to the freshwater *Hemisinus* and *Planorbis* gastropods (Trechman, 1941). At All Saints section (34 m- thick; Fig.2, Appendix 1.5), located in the centre of the island, we found, from bottom to top:

- 21.5 m- thick alternance of six superimposed mudflow to debris flow deposits composed of andesitic, cm- to dm- sized volcanic fragments, with an erosive base. Some conglomerates interbeds show cross bedding structure indicative of a transport of the sediments towards the NE.
- 9 m- thick green silty clays with interbedded tuffitic HCS and tuffitic microbreccias into flat channels. The uppermost part of these units comprises fine-grained tuffitic deposits with frequent accretionary lapillis and is devoid of fossils. Within the channels, prograding lenticular beds of coarse-grained sediments indicate a transport of the sediments towards the NE.

To the SE, the volcanoclastic deposits of the CPG are topped by lacustrine limestones (Martin-Kaye, 1959, Fig.2) which are mostly devoid of fossils, except rare ostracods. Several facies are recorded within these limestones: some beds are very fine-grained clayey carbonates, other are silty claystone with some diatomitic laminae, other are laminated peloidal packstone with some sparse amphibole and feldspath grains.

From these outcrops, we interpret a depositional setting corresponding to an alluvial plain system with lakes and ephemeral braided alluvial fans (Nemec and Steel, 1984), at the foot of a volcanic edifice located to the SW and corresponding nowadays to the Basal Volcanic Suite (BVS). Episodic volcanic activity is recorded, with tuffites and lapillis deposits.

Antigua Formation

In the northwestern part of the island, the synthetic Antigua Fm succession is established from isolated outcrops (St-John, Fort-James, Piggots, Marble Hill, Military Camp,

APPENDIX 2

MICROFACIES AND LARGER BENTHIC FORAMINIFERA CONTENT

Plate 1

Scale bars: Figs 1-8 = 0.5mm

1. *Eulepidina favosa* (Cushman). ANT21.01.3A

2-3. *Lepidocyclina* (*Lepidocyclina*) mantelli (Morton), 2) ANT21.01.3A, 3) ANT24.01C

4. *Eulepidina undosa (*Cushman), ANT28.01

5. a) *Heterostegina antillea* (Cushman), b) *Eulepidina* sp., ANT28.01

6. a) *Catapsydrax* sp., b) *Lepidocyclina* (*Lepidocyclina*) *mantelli* (Morton), ANT24.01B

7. a) *Victoriella* sp., b) *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* (Cushman), ANT22.01B

8. *Heterostegina ocalana* (Cushman), ANT22.01A

Plate 2

Scale bars: Figs 1-4 = 0.3mm

1. *Catapsydrax dissimilis* (Cushman and Bermudez) ANT22.01-1G

2. *Globigerinoides primordius* (Blow and Banner), ANT22.01-1D

3. a) *Globigerina praebulloides* (Blow), *Globigerinoides primordius* (Blow and Banner), c) *Paragloborotalia nana* (Bolli), ANT22.01-1D

4. a) Fragments of *Eulepidina* sp., b) *Globigerina praebulloides* (Blow), c) *Globigerina ciperoensis* (Blow), d) *Globigerina angulisuturalis* (Bolli), e) *Globigerinoides primordius* (Blow and Banner), ANT22.01F

Plate 1

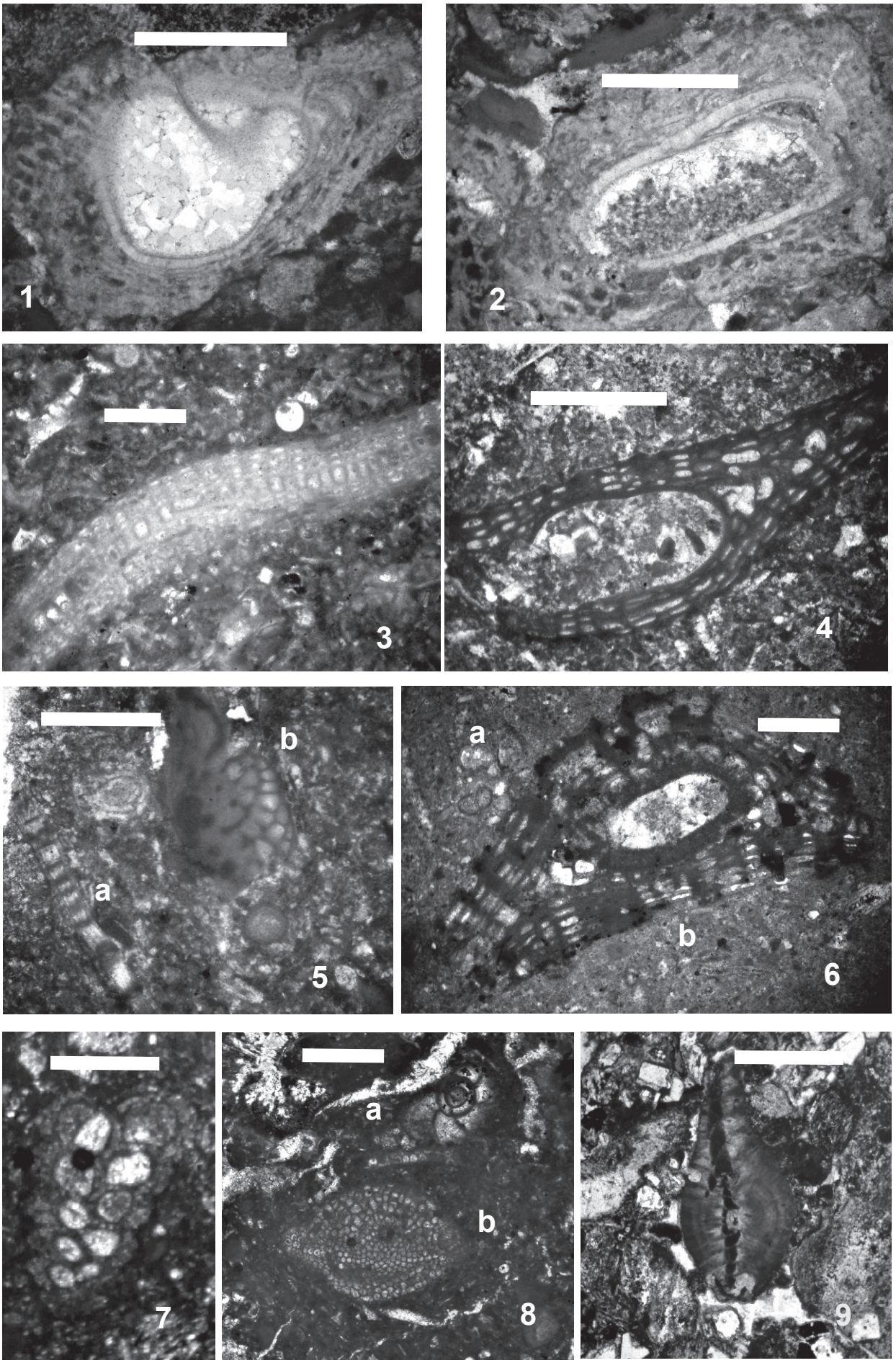
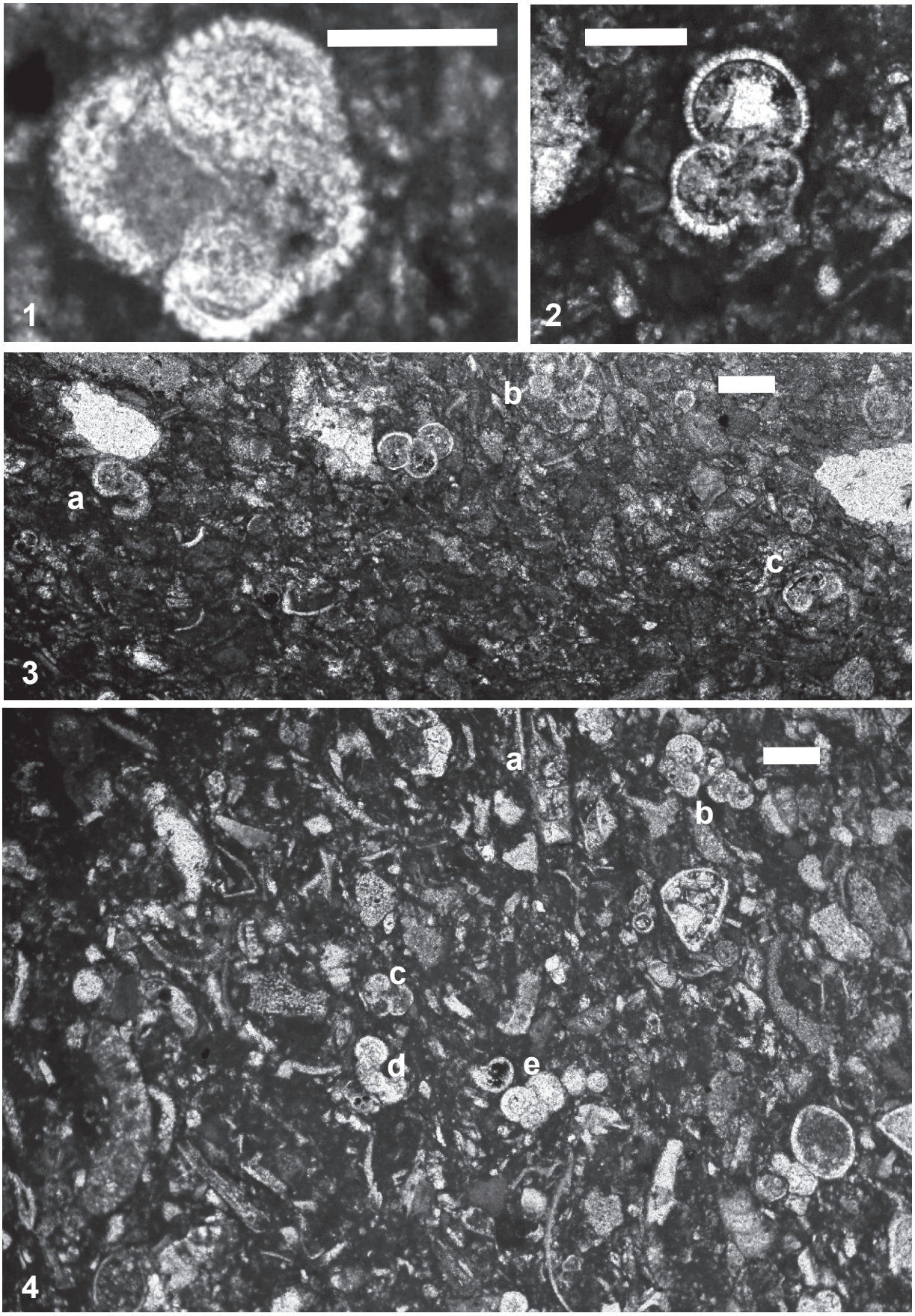


Plate 2



Five Island; Fig.2, Appendices 1.2, 1.3) and from the Burma quarry section (*ca* 80 m- thick; Fig.2, Appendix 1.4). It comprises from bottom to top :

- 10 m-thick crossbedded coarse-grained limy volcaniclastic deposits containing red algae and large benthic foraminifera (*Operculinoides*) that are found in St-John and Fort James. At St-John, these beds rest upon a 8 m-thick silty clays tilted toward the NE belonging to the CPG above an erosional unconformity (Fig.4A);
- 18 m-thick and foraminifera-rich packstone cropping out as isolated outcrops (Marble Hill; Military Camp). The benthic foraminifera (*Heterostegina, Lepidocyclina*) and planktonic foraminifera (*Paragloborotalia*) point from Zones P18-P21a in the lower part (Rupelian, 33.9-28.1 Ma) to P21b (Chattian, 28.1-26.8 Ma) (Appendix 1.3, Appendix 2);
- 45 m- thick of m-thick alternating beds of coral biostromes and wackestone to packstone of red algae and larger benthic foraminifera (Burma quarry; Appendix 2.4). Biostromal beds are composed of mostly in life position short-branching, sheet-like and massive coral colonies. The bioclastic beds yielded red algae, thin-shelled, spiny bivalves and some isolated coral colonies. The reefal succession is interrupted by two green volcaniclastic and carbonate microbreccias levels. The benthic foraminifera collected in the lowermost part of the succession provided larger benthic foraminifera (Appendix 1.4) that point to Zones P21-P22 (late Rupelian-Chattian). This is concordant with Sr isotope dating that indicates the 25.9-26.9 Ma interval (P21b, Robinson et al, 2017). The uppermost part of the succession remains undated.

These deposits were first emplaced into high-energy inner carbonate ramp setting changing upward into inner to mid ramp setting during the early Chattian. During the late Chattian (P22), a coral platform with a diverse coral fauna has been emplaced.

In the central-western part of Antigua, we reconstruct the succession from three quarries (Pares, Parnham and Newfield; Appendix 1.6 to 1.9) with, from bottom to top:

- 10 m- thick coarse grained mixed carbonate and volcaniclastic grainstone with pieces of corals and red algae (Pares and Parnham quarries) or dm- thick coral beds (corals are either in life position or as rubbles; Newfield). Mega-ripples, channels and low angle progradations are recorded and indicate a transport toward the NNE/E. The benthic foraminifera point to Zones P18-P21a (Rupelian, 33.9-28.1Ma) (Appendix 1.7);
- 8 m-thick packstone of benthic foraminifera, red algae and bivalves with thin- branched coral colonies beds. At Newfield the succession is topped with an erosional surface, which is overlaid by a mixed carbonate-volcaniclastic breccia. At Pares and Parham, two crossbedded

volcanoclastic levels are interbedded within the limestones. The benthic foraminifera (*Eulepidina*, *Heterostegina*, *Neorotalia*) and rare planktonic foraminifera (*Paragloborotalia*) point to Zones P21b-P22 (Chattian, 27.8-23 Ma). At Newfield, the benthic foraminifera point to Zones P21-P22 (late Rupelian-Chattian, 29.2-23 Ma).

- 5.5 m- thick wackestones with foraminifera at Newfield. The benthic foraminifera point to Zones P21-P22 (late Rupelian-Chattian (Appendix 1.9). The uppermost part of the succession is made of 18 m- thick fine-grained packstone to mudstone with benthic and planktonic foraminifera. Four levels of normally graded sandy volcaniclastics are interbedded within the limestones. At Pares, the benthic and the planktonic foraminifera (*Heterostegina*, *Lepidocyclina*, *Eulepidina*, *Paleomiogypsina, Globigerina*, *Paragloborotalia*) point to Zones P21b – P22 (Chattian) in the lower part of the section, and Zones P22b to P22b-N4 in the upperpart (late Chattian-Aquitanian, 24-21 Ma).

This sucession indicates that during the Rupelian the sediments were deposited into a reefal, high energetic inner platform. During the early Chattian, the depositional setting was first a low energy reefal platform, that changed in the late Chattian to low energy, muddy outer plaform or ramp environment rich in planktonic foraminifera indicating a deepening upward trend.

At Newfield, lateral variation is observed with the reefal beds changing into forereef breccia to the NE. These are overlaid by fragments of rafted reefal beds which slided to the NE. The rafts are topped by NE dipping forereef coral rubble beds (Fig. 4B). This indicates that this area was on the edge of the reef platform and that deeper environments existed to the NE. Such a short transition from reef to slope forereef and the presence of rafted beds suggest the presence of neighbouring faults with syn-sedimentary activity.

In the southern and southeastern part of Antigua (Appendix 1.10 to .12) we found three isolated outcrops that lay above the CPG (Pigeon Beach, Galleon and Willoughby bay, Fig.2). At Pigeon Beach, 8 m- thick packstones of larger benthic foraminifera with massive coral colonies overlay andesitic breccias of the BVS. The benthic foraminifera (*Eulepidina*, *Miogypsina*, *Lepidocyclina*) point to Zone P20 (Rupelian, 30.3-29.2 Ma). Similar outcrops are found at Galleon and Willoughby Bay, where floatstones of large benthic foraminifera and branching coral colonies lays on volcanic breccias and crossbedded conglomerates of the CPG. The larger benthic foraminifera point to Zone P18-P21a (Rupelian, 33.9-29.2 Ma) and P21b-P22 (Chattian, 28.1-23 Ma).

Further east, two sections (Halfmoon Bay, Devil's Bridge, Fig.2, Appendix 1.11, 1.12) that are part of the Antigua Fm (according to the delimitation of Martin-Kaye, 1959) were

logged. At Half Moon Bay, wackestones of planktonic foraminifera and larger benthic foraminifera are interbedded with wackestones to packstones that contain a mixture of coastal and deep-sea fauna (corals, echinoids benthic and planktonic foraminifera). The foraminifera (*Eulepidina undosa*, *Streptochilus cubensis*) point to Zones P18-P21a (Rupelian, 33.9-29.2 Ma). At Devil's Bridge, the succession is composed of 6.5 m- thick bioturbated wackestones with planktonic foraminifera. The wackestones are interbedded with coarse-grained packstones containing transported shallow water fauna (corals, echinoids, larger benthic foraminifera…). The planktonic foraminifera (*Globigerina*, *Globigerinoides*, *Paragloborotalia*, *Captasydrax*) point to Zones P22-N4 (late Chattian-Aquitanian, 26.8-21 Ma).

The lowermost part of the marine limestones in southern Antigua are shallow water reefal deposits which directly rest on the BVS or the CPG. At Half Moon bay, Rupelian deposits change into mid to outer ramp deposits with tempestites interbeddings. During the Chattian corals reefs (0-20 m depth) have locally been emplaced, then a deepening upward occurred with mid-outer ramp (30-100 m depth) and tempestite deposits during the late Chattian-Aquitanian as showned by the rocks at Devil's Bridge.

REFERENCES CITED

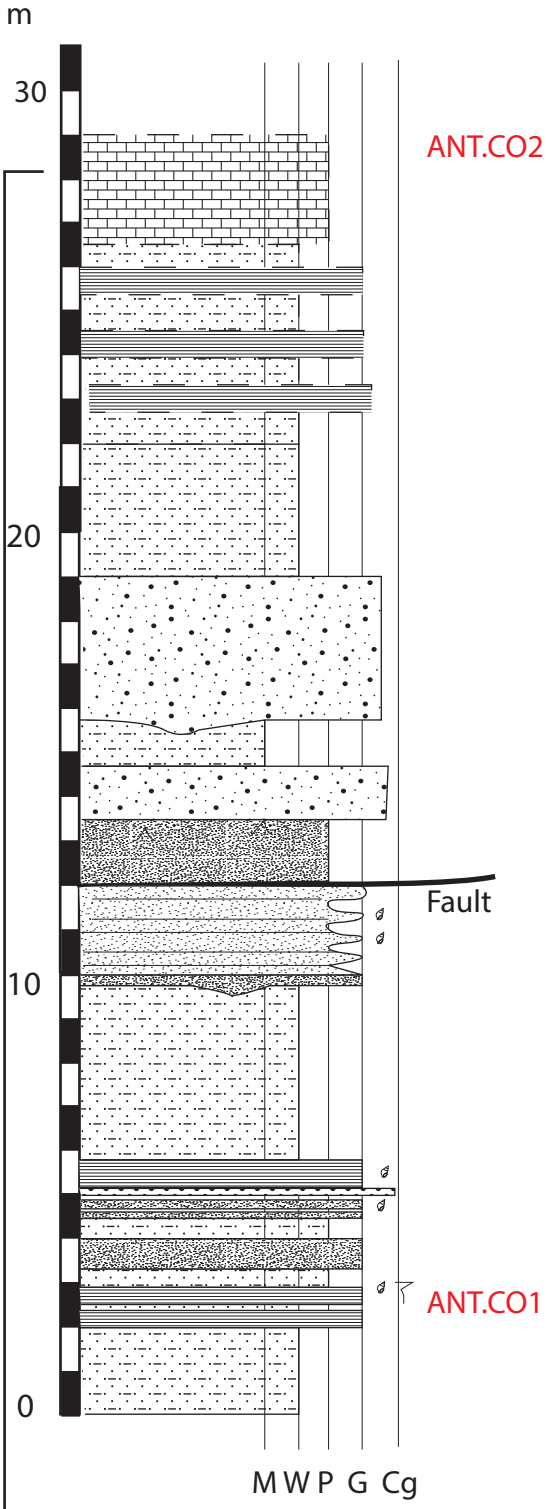
Martin-Kaye, P.H.A., 1959, Reports on the geology of the Leeward and British Virgin Islands. Voice Publishing Co., Ltd., St. Lucia, W.I., p.117.

Nemec, W., and Steel, R.J., 1984, Alluvial and coastal conglomerates: their significant features and some comments on gravelly mass-flow deposits. In: Koster, E.H., Steel, R.J. (Eds.), Sedimentology of Gravels and Conglomerates. Mem. Can. Soc. Petrol. Geol., v.10.

Robinson, E., Paytan, A., and Chein, C.-T., 2017, Strontium isotope dates for the Oligocene Antigua Formation, Antigua, W. I: Caribbean Journal of Earth Science, v. 50, p. 11–18.

Trechmann, C.T., 1941, Some observations on the geology of Antigua, West Indies: Geological Magazine, v. 78, p. 113–124, https://doi.org/10.1017/S0016756800071806.

ANTIGUA, CORBISON BEACH, SITE CO, CENTRAL PLAIN GROUP

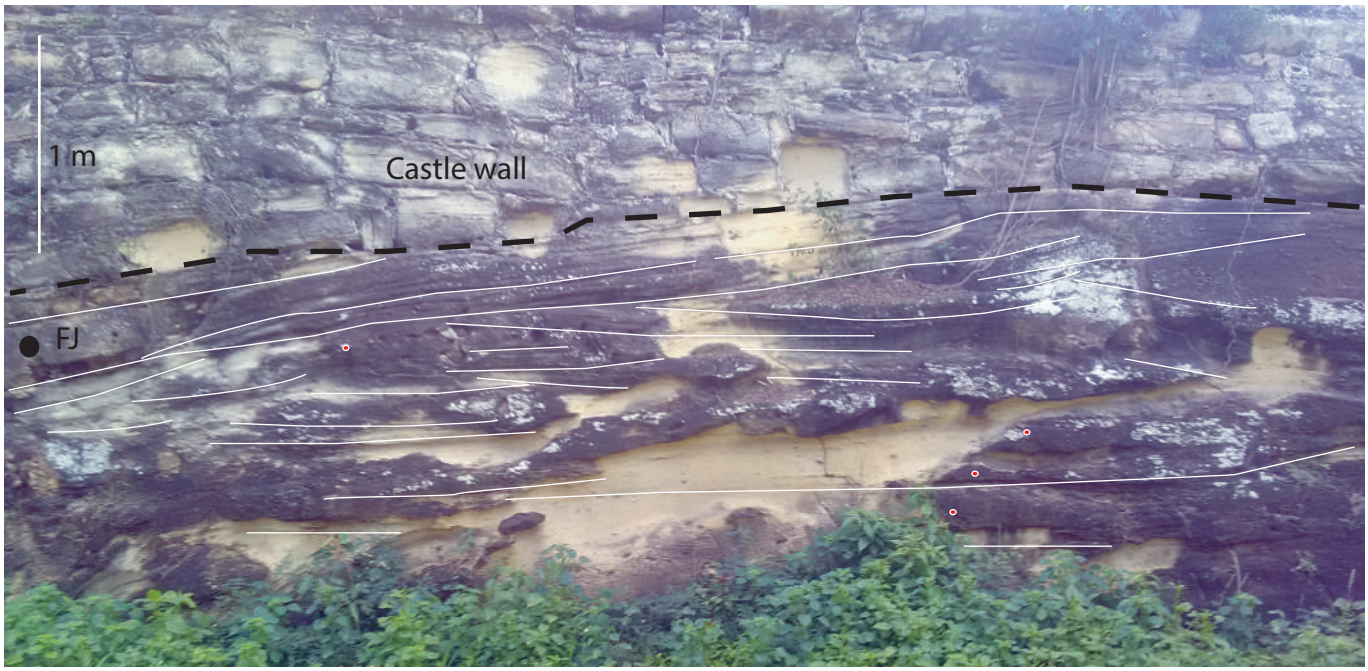


White mudstone, silicification, benthic ostracods	Lacustrine with andesitic debris flows and tuff interbeds
Silty clays and silicified tuffitic beds	
Yellow silty clay	
Volcanoclastic, cm- sized debris flow	
Green clay	
Volcanoclastic, cm- sized debris flow	
Purple volcaniclastic clayey sandstone, gas escape structures	
Interbedded volcaniclastic sandstones and clays, parall laminations, silicification	
Cm- bedded silty clay, mm- sized volcanic debris	
Silicified tuffitic microbreccia	
Microconglomeratic sandstone	
Clayey sandstone, ripple marks	
Sandy/volcanoclastic clay	
Yellow silicified tuffaceous microbreccia, terrestrial gastropods and ostracods	
Green silty clay	

Hemisinus and *Planorbis*, freshwater gastropods

FORT JAMES PARKING
LOWER PART OF THE ANTIGUA FORMATION

NE



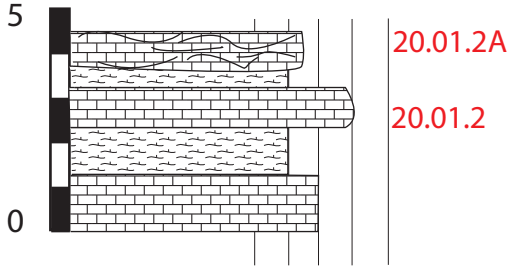
SW

Crossbedded limy sandstones with andesite grains, feldspar grains, some red algae; progradation toward NNE-NE. High energy inner platform or ramp.

ISOLATED OUTCROPS IN THE NORTHWESTERN PART OF ANTIGUA

Inner platform, reefal

PIGGOTS, SITE 20.01.2



Nodular fine grained limestone with undetermined microfossils
Clayey limestone with corals
Rudstone to packstone of oysters, red algae, corals, larger benthic foraminifera
Clayey limestone

Bioclastic limestone

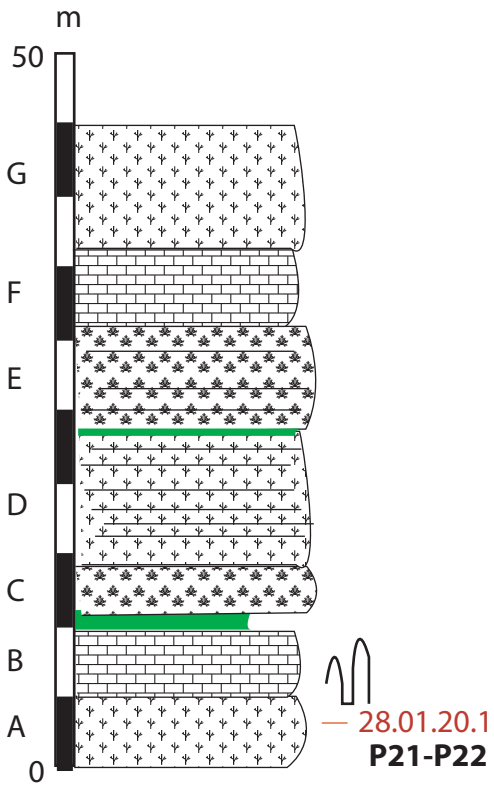
Sample	Facies	Clasts	Foraminifera	Depositional setting	Age
ANT 28 MARBLE HILL	Packstone of foraminifera	Benthic foraminifera, red algae, echinoids, some planktonic foraminifera	*Daviesina* sp., *Neorotalia* sp., *Heterostegina israelskyi*, *Lepidocyclina* sp., *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis*, *Lepidocyclina* (*Nephrolepidina*) *braziliana*, *Eorupertia* sp., *Paragloborotalia nana*	Inner/mid ramp or platform–	Rupelian P18-P21, 33,9-28,1 Ma
ANT 32 MILITARY CAMP ENTRANCE	Mudstone	Planktonic foraminifera	*Paragloborotalia nana, P. opima, Globigerina* sp.	Outer ramp	Late Rupelian-early Chattian, P21, 29.2-26.8 Ma
FI	Mudstone to wackestone, laminations, volcanic debris associated with volcaniclastic grainstones	Planktonic foraminifera	*Globigerina angulisuturalis, Globigerina ciperoensis*, questionable ?*Globoturborot-alita ouachitaensis*	Mid to outer ramp	Oligocene-earliest Miocene, N20-N4, 33.9-21 Ma, possibly P21b 28.126.8 Ma

Vertical stylolithes

ANTIGUA, BURMA QUARRY, SITE BU

Schematic section

volcaniclastic deposit

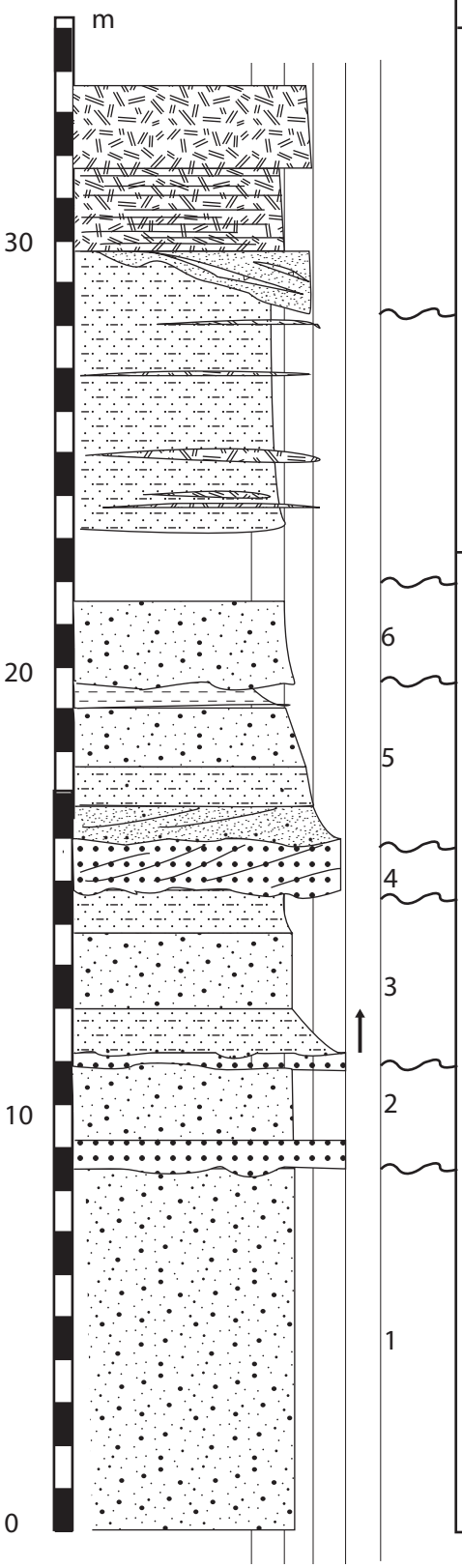


Lithology	Depositional environment
Coral beds of sheet-like or massive colonies, some clay upward, and packstone of undetermined larger benthic foraminifera, oysters and red algae	Low energy, inner reefal platform or ramp
Grey wackestone to packstone, some coral beds of massive colonies	
Coral beds with massive and branching colonies, interbedded packstones with spiny bivalves and coral debris	
Dm- thick coral beds	
Thin- branched coral beds and packstones	
Dm- thick packstones of red algae and benthic foraminifera	
Fine-grained packstones with some massive coral colonies, red algae, larger benthic foraminifera, spiny molluscs	

Sample	Facies	Bioclasts	Foraminifera	Age
ANT 28-01-20-1	Wackestone of benthic foraminifera,	Benthic foraminifera, red algae, bivalves	*Eulepidina undosa*, *Heterostegina antillea*, *Lepidicyclina* (*Lepidocyclina*) *mantelli*	P21-P22 Late Rupelian Chattian 29.2-23 Ma
EP3141	Sr Age Robinson et al., 2017 in Unit A			25.9-26.9 Ma P22a Chattian

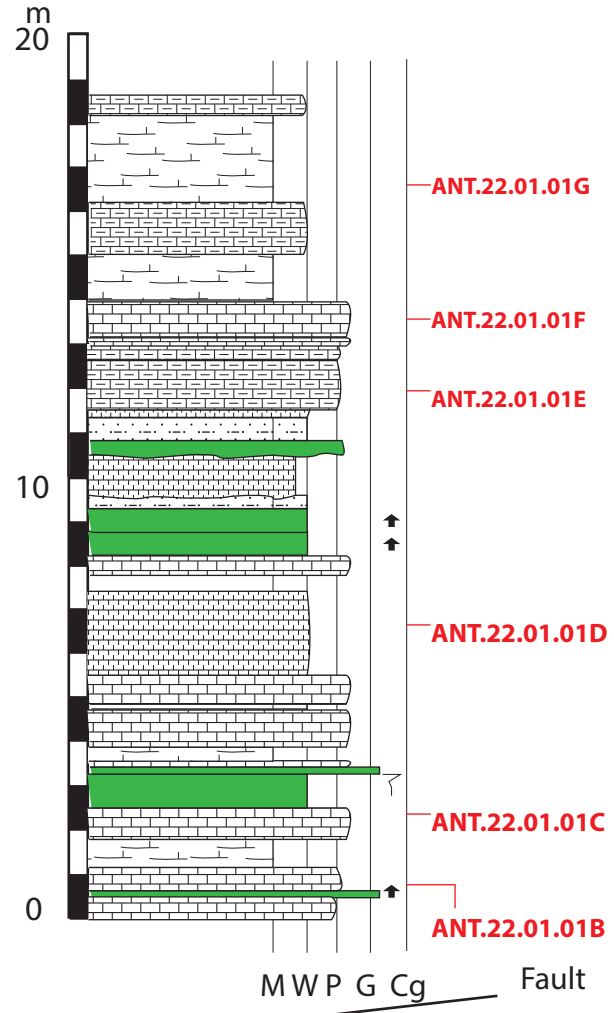
Vertical stylolithes

ALL SAINTS, CENTRAL PLAIN GROUP, SITE TU

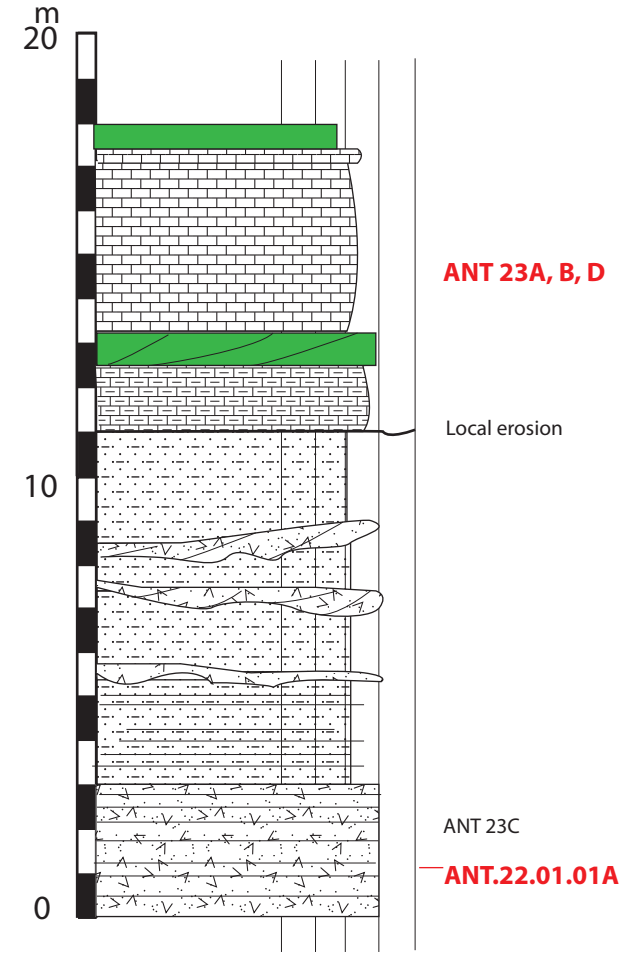


Lithology	Depositional setting
Very fine-grained tuffite, accretionary lapillis - ANT 19-01-1B Reworked tuffite, accretionary lapillis Microbreccia and reworked tuffite in channel Clays, microbreccia and fine-grained tuffitic HCS - ANT 19-01-1A with plagioclase crystals	Alluvial plain with volcaniclastic interbeddings
Massflow with andesite cobbles Silty clays Mudflow with andesite cobbles Silty to sandy clay Andesite conglomerate, crossbedding Debris flow with andesite blocks; crossbedding Mudflow with andesite cobbles Horizontally laminated silty to sandy clay Mudflow with andesite gravels Debris flow with andesite debris Mudflow with andesite cobbles	Alluvial fans prograding towards NE to fluvial

ANTIGUA, PARES QUARRY, SITE ANT.22.01.01
North of the fault



ANTIGUA, PARES QUARRY
South of the fault



Lithology	Dep. setting	Age
Mudstone to wackestone of planktonic forams, nodular structure	Mid to outer ramp	Latest Chattian-Aquitanian
Fine-grained wackestone to packstone of planktonic forams and fine-grained volcaniclastics		
Graded bedded volcaniclastics, turbidites?		
Fine-grained wackestone to packstone; dcm- thick ondulated beds	Inner to mid ramp	
Fine-grained packstone of benthic forams, red algae, irregular echinoids, Ditrupa; graded bedded volcaniclastics		Chattian
Tuffaceous clays		
Packstone of red algae, lepidocyclinids, bivalves, echinoids, some corals		
Volcaniclastic limestones with coral debris		
Fine-grained limestone, rhodolithes, oysters, *Halimeda*		
Sandy-clayey microbreccia, volcanic grains; cm- thick bedding with erosional coarse-grained volcaniclastics (flat channels) and megaripples	Inner ramp	
Volcaniclastic and lime microbreccia, cm- thick beds; red algae , corals and molluscs		Rupelian

General deepening upward trend

PARES SECTION, FORAMINIFERA

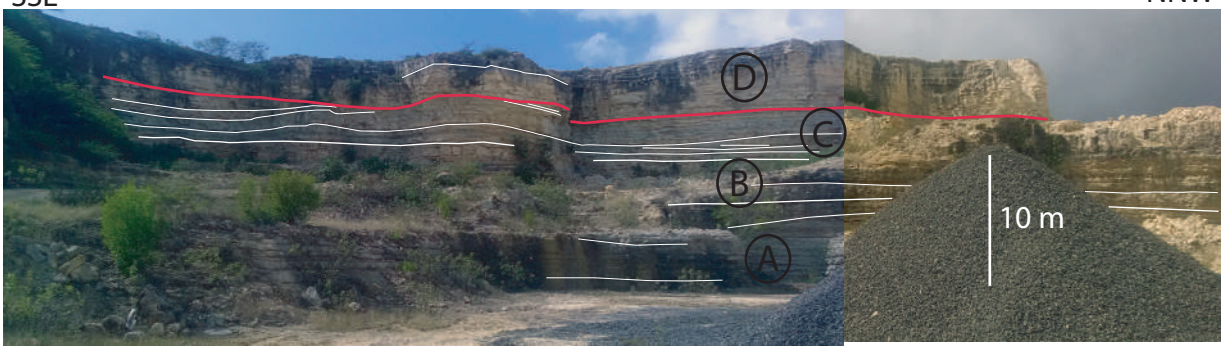
Sample	Facies	Clasts	Foraminifera	Depositional setting	Age
PARES QUARRY ANT 23					
ANT.22.01.01G	Wackestone of planktonic foraminifera	Planktonic foraminifera, some benthic ones, some echinoids, red algae and molluscs	*Catapsydrax dissimilis, Paragloborotalia nana, Globigerina praebulloides, Brizalina* sp., *Globigerinoides* sp.,*G. primordius*	Outer ramp or platform	Latest Chattian-Aquitanian, P22b-N4, 24-21 Ma
ANT.22.01.01F	Wackestone of planktonic foraminifera	Planktonic foraminifera, some benthic ones, some echinoids, red algae and molluscs	*Paleomiogypsina* sp., *Nodosaria* sp., *Eulepidina favosa, Paragloborotalia nana, Globigerina angulisuturalis, Eponides* sp.	Outer ramp or platform	Chattian, P22b, 24-23 Ma
ANT.22.01.01E	Wackestone of planktonic foraminifera	Planktonic foraminifera, benthic ones, encrusting red algae, rare corals	*Paragloborotalia nana, Heterostegina antillea, Planorbulinella* sp., *Lepidocyclina* sp., *Eulepidina* sp., *E. favosa, Lenticulina*	Mid to outer ramp of platform	Chattian, P22b, 24-23 Ma
ANT.22.01.01D	Wackestone of planktonic foraminifera	Planktonic foraminifera, some benthic foraminifera	*Victoriella* sp., *Paragloborotalia nana, P.* sp. *Globigerina praebulloides, , Globigerinoides primordius, Globigerina* sp. *Paleomiogypsina* sp .	Outer ramp or platform	Chattian, P22b, 24-23 Ma
ANT.22.01.01B	Wackestone to packstone of benthic foraminifera	Benthic foraminifera, spiny molluscs, bryozoans, sponge spicules, red algae, some volcanic clasts	*Carpenteria* sp., *Victoriella* sp., *Lepidocyclina* sp., *Eulepidina favosa,*	Inner to mid ramp or platform	Chattian, P21b-P22, 28.1-23 Ma
ANT.22.01.01B	Wackestone to packstone of benthic foraminifera	Benthic foraminifera, spiny molluscs, bryozoans, sponge spicules, red algae, some volcanic clasts	*Carpenteria* sp., *Victoriella* sp., *Lepidocyclina* sp., *Eulepidina favosa*	Inner to mid ramp or platform	Chattian, P21b-P22b, 28.1-23 Ma
ANT 23	Packstone of larger benthic foraminifera, peloidal matrix	Larger benthic foraminifera, echinoids, bryozoans, red algae, gastropods, bivalves, some planktonic foraminifera, encrusting foraminifera, dasycladals and corals	*Daviesina* sp., *Neorotalia* sp., *Heterostegina israelskyi*, *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis*, *L.* (*Nephrolepidina*) *braziliana*, *Eorupertia* sp., *Paragloborotalia nana*	Low energy, open sea inner platform or ramp	Chattian, P21b-P22, 28.1-23 Ma
ANT.22.01.01A	Sandy to microbbreccia packstone, plane crossbedding	Benthic foraminifera, green algae, echinoids, corals, micritic grains, lava clasts, quartz	*Heterostegina ocalana, Eulepidina* sp., *E.* cf. *undosa,*	High energy inner ramp or platform	Rupelian, P18-P21a, 33.9-28.1 Ma

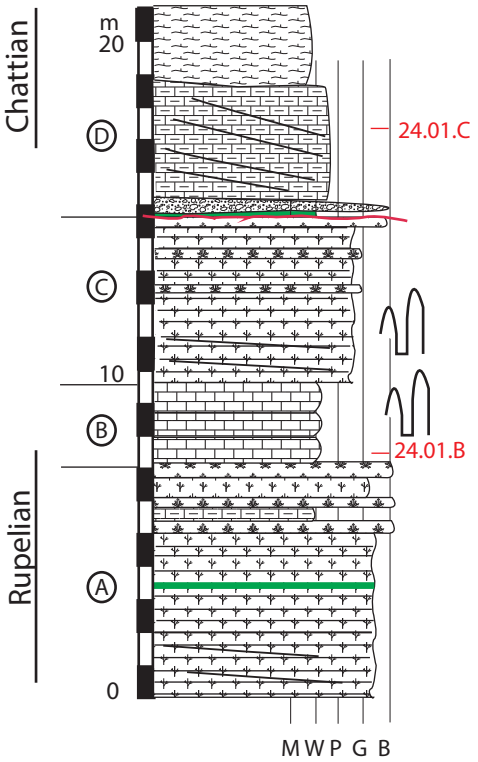
ANTIGUA, PARNHAM QUARRY, SITE PAR2

ANTIGUA, ANT 24, NEWFIELD QUARRY

Southern part

SSE NNW





Lithology	Depositional setting	T/R cycles
White nodular wackestone with planktonic foraminifera	Mid to outer platform	T
Dm- wackestone with oysters and benthic foraminifera and packestone with some corals; flat channels and progradation to NNE	Inner to mid reefal platform (deep forereef)	
Volcaniclastics and lime breccia	***Erosional surface***	
Dm- thick grey to yellow wackestone to packstone with small branching coral colonies in some beds; lenticular bedding; larger benthic foraminifera, pectinids, oysters, red algae	Low energy, inner reefal coral platform	
Massive wackestone of benthic foraminifera (lepidocyclinids), red algae, pectinids..		
Coral beds with massive and branching colonies and thin branched corals and larger benthic foraminifera clayey floatstone		
Dm-thick interbeds of branched coral biostromes and coral rubbles; pectinids, oysters, echinoids. One clayey volcaniclastic microbreccia Locally prograding beds toward NE and NNE	High energy, outer edge of reefal platform (forereef)	

Sample	Facies	Bioclasts	Foraminifera	Age
ANT 24-01-01- C	Packstone	Benthic foraminifera, bryozoans, echinoids, red algae, some plan-ktonic foraminifera	*Eulepidina undosa*, *Heterostegina antillea* *Lepidocyclina* (*L.*) *mantelli*	P21-P22 latest Rupelian Chattian
ANT-24-01-01-B	Packstone	Benthic foraminifera, oysters, red algae corals	*Eulepidina undosa*, *Lepidocyclinna* (*L.*) *yurganensis* *Lepidocyclina* (*L.*) *mantelli*	P18-P21a Rupelian

Vertical stylolithes

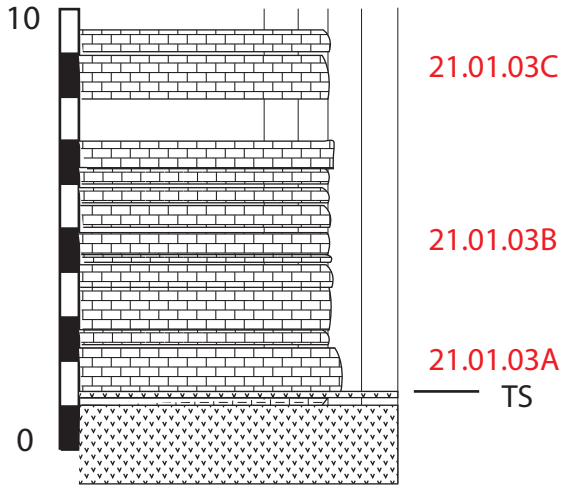
NELSON DOCKYARD

Large scale crossbeds

NELSON DOCKYARD	Grainstone, sparite cement	Benthic and planktonic foraminifera, red algae	*Dentoglobigerina venezualensis, Lepidocyclina* (*L.*) *yurganensis, Carpenteria* sp., *Neorotalia* sp.	Inner ramp or platform, high energy	Rupelian-early Chattian, P18-P21, 33.9-29.2 Ma

PIGEON BEACH, SITE PB

TS: transgression surface



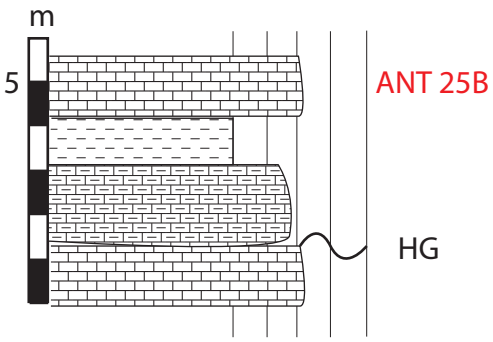
Lithology	Dep. setting	Age
Packstone to floatstone of larger benthic foraminifera, red algae, bivalves, corals (debris, thin-sheeted colonies, rare massive ones, local bindstone)	High energy inner ramp	Rupelian
Andesite breccias	Terrestrial	

ANT 21-01-3C	Wackestone of benthic foraminifera	Operculina, red algae, gastropods, echinoids,	?	Inner ramp or platform, low energy	Cenozoic
ANT-21-01-3B	Wackestone of benthic foraminifera	Benthic foraminifera, red algae	*Americogypsina koutsoukosis, Planorbulina* sp., *Operculina* sp., *Miogypsinella* sp.	Inner ramp or platform, low energy	Rupelian P20, 30.3-29.2 Ma
ANT-21-01-3A	Wackestone of red algae	Benthic foraminifera, red algae	*Eulepidina favosa, Eulepidina undosa, Lepidocylina* (*Lepidocyclina*) *yurnagunensis*	Inner ramp or platform, low energy	Rupelian, P18-P20, 33.9-29.2 Ma

NE

ISOLATED OUTCROPS IN THE SOUTHEASTERN PART OF ANTIGUA

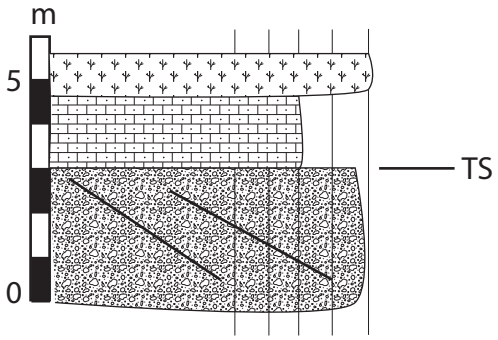
HALF MOON BAY, SITE ANT 25



Lithology	Dep. setting	Age
Bioclastic wackestone	Mid to outer ramp or platform	Rupelian P20-P21a
Wackeston of planktonic foraminifera, deep water sponges, crinoids and brachiopods		
Clayey limestones with echinoids, larger benthic foraminifera		
Wackestone with larger benthic and planktonic foraminifera; transported corals; hard ground at top		

ANT 25B	Wackestone of planktonic foraminifera	Planktonic foraminifera, Benthic foraminifera	*Eulepidina undosa, Streptochilus cubensis, Liebusella* sp.	Mid-outer ramp or platform, low energy	Rupelian, P18-P21a, 33.9-28.1 Ma

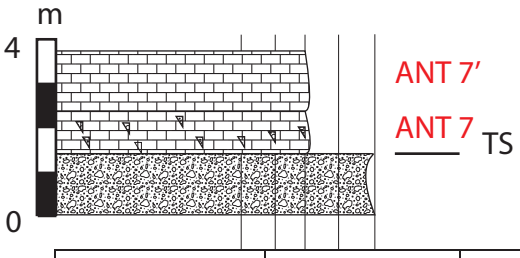
WILLOUGHBY BAY, SITE ANT 20



Lithology	Dep. setting	Age
Coral boundstone, branching and massive colonies	Inner ramp, reef	?
Sandy limestone with benthic foraminifera		
Volcaniclastic breccia	Alluvial fan	

TS: transgression surface; HG: hard ground

SITE ANT 7



Lithology	Dep. setting	Age
Packstone of larger benthic foraminifera	Inner ramp	Chattian
Breccia packstone with larger benthic foraminifera		Rupelian
Volcaniclastic breccia	Terres-trial	?

ANT 7'	Packestone ot benthic foraminifera	Benthic foraminifera	*Eulepidina undosa, Miogypsina intermedia, Operculinoides* sp.	Inner ramp or platform	Chattian, P21b-P22, 28.1-23 Ma
ANT 7	Packstone ot benthic foraminifera	Benthic foraminifera, corals, red algae, lavas	*Eulepidina* sp, *E. undosa, Amphistegina* sp., *Operculinoides jacksonensis, Lepidocyclina* sp., *L.* (*Lepidocyclina*) *yurnagunensis*	Inner ramp or platform, reefal	Rupelian, P18-P21a, 33.9-29.2 Ma

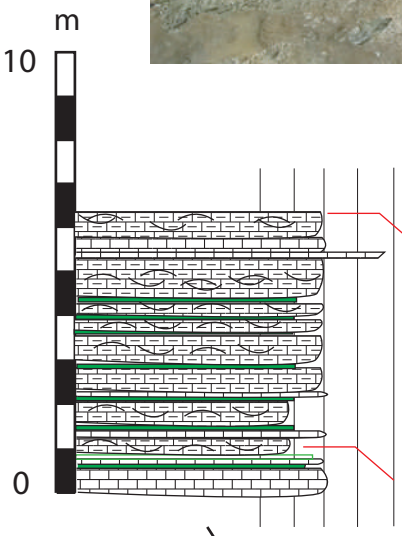
SW

DEVIL'S BRIDGE, NE ANTIGUA, SITE DB

White wackestone with planktonic foraminifera and bioturbation

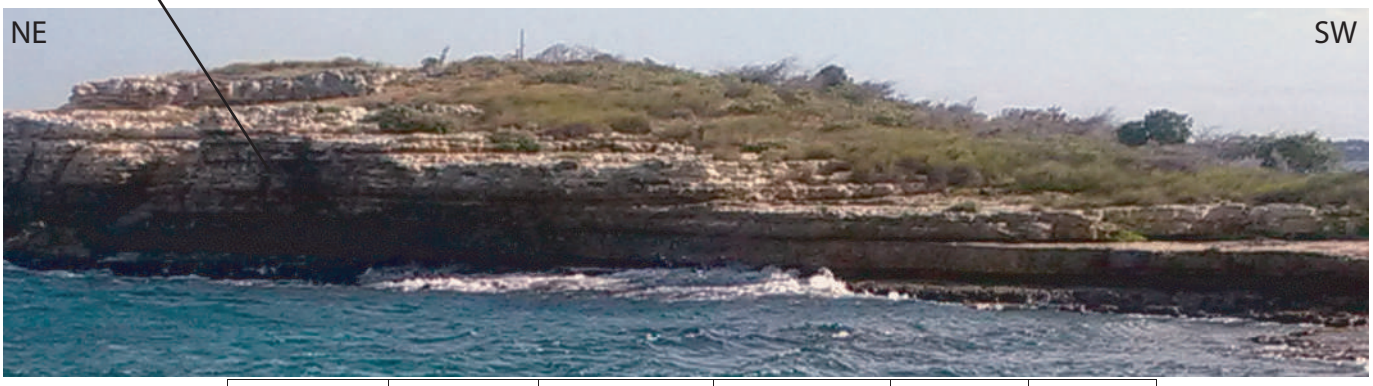
Yellow packstone interbed with volcanic clasts and littoral-derived bioclasts; tempestites

Packstone with volcanic clasts



Lithology	Depositional environment
Clayey white wackestone to packstone with planktonic foraminifera and some red algae, displaying lense-shaped nodular diagenetic structures. Interbeds of high energy packstones with littoral fauna (corals, larger benthic forams, echinoids, red algae...) and of lime volcaniclastic deposits (tempestites?) ANT.23.01.04	Mid to outer ramp or platform **P21-P22**

Laterally below: Oligocene, **P21**, 29,2-26,8 Ma, **late Rupelian-early Chattian,** ANT 27



Sample	Facies	Clasts	Foraminifera	Depositional setting	Age
ANT-23-01	Wackestone of planktonic foraminifera	Planktonic foraminifera	*Amphistegina* sp., *Bolivina* sp., *Globigerina* sp., *G. praebulloides, Catapsydrax dissimilis, Globigerinoides primordius, Paragloborotalia nana.*	Outer platform or ramp	Latest Oligocene-Aquitanian, P22b-N4 24-21 Ma
ANT 27	Coral boudstone	Bivalves, encrusting red algae, echinoids, bryozoans, benthic foraminifera, rare planktonic foraminifera, peloids	*Lepidocyclina* (*L*) *pustulosa* .	Inner platform, reef	Late Rupelian-Early Chattian, P21, 29.2-26.8 Ma

APPENDIX 3

DESCRIPTION OF THE SEISMIC PROFILES 508 AND 510

To constrain the post-Oligocene evolution of Antigua and integrate its onshore geology in a regional context, we used seismic line 508 and 510 from the Comité d'Etude Pétrolière et Marine (CPEM) that were acquired by the Antilles IV cruise in the 1970's (e.g., Bouysse et al., 1985, Bouysse and Mascle, 1994) under the supervision of the Institut Français du Pétrole et des Energies nouvelles (IFPEN), that were interpreted by Cornée et al, (2021).

On the seismic profiles of lines 508 and 510 three sedimentary megasequences (MS4, MS5 and MS6-7) are identified above an acoustic basement (Fig. 11A). These megasequences are bounded by unconformities that were recognized regionally in the north-eastern Lesser Antilles (Cornée et al., 2021) and in the V-shaped basins of the outer forearc (Boucard et al., 2021). As lines 510 and 508 cross, we integrate the seismic line 508 into a time calibrated seismic stratigraphy analysis (Fig. 11B). The megasequences were time- calibrated using dredges from three oceanographic cruises, correlation with two deep drill holes in the Saba Bank and onshore- offshore correlations (Cornée et al., 2021).

- The megasequence MS4, late Oligocene to early Miocene in age, rests upon the acoustic basement (MS 1) above the erosional SB3. It comprises up to 1.5 stwtt- thick gently-dipping reflectors onlapping the basement highs. The sequence ends with the major erosional surface SB4, early-middle Miocene in age, that truncates the MS4 reflectors. On the seismic 508, MS4 is crosscut by E-W trending normal faults defining horsts and grabens, which are sealed by the overlying megasequence MS5.

- The megasequence MS5 is middle Miocene to early Pliocene in age with a thickness ranging between 0.5 and 0.75 stwtt. It comprises medium to strong amplitude, parallel and continuous reflectors, except on Antigua where it gets thinner. The MS5 is topped by the unconformity SB5. SB5 is characterized by an abrupt change of the seismic facies, localized truncations of MS5 and low-angle onlaps of the overlying MS6.

- The megasequence MS6-7, Pliocene to Holocene, is 0.5 to 1 stwtt- thick. In the basin areas, it comprises medium- to strong- amplitude, medium-frequency,

continuous and parallel reflectors. On the margins of the Antigua Bank, reflectors are organized into prograding-aggrading geometry. MS6-7 locally displays onlaps above SB. MS5 to 7 are vertically stacked and deposits mimic the topography of this underlying high. The Antigua Bank is bounded by two main faults: -to the south, MS4 is crosscut by an E-W trending normal fault with southward offset; and to the north-east by a N-S trending fault relayed by a NW-SW fault with apparent offset to the north-east. The presence of early Miocene deposits onshore in Antigua Island was probable as it is surrounded by such deposits offshore (presence of MS5 deposits south, west and east of Antigua; early Miocene deposits in dredge Arcante 79D). (Fig. 11C).

REFERENCES CITED

Boucard, M., Marcaillou, B., Lebrun, J. -F., Laurencin, M., Klingelhoefer, F., Laigle, M., Lallemand, S., Schenini, L., Graindorge, D., Cornée, J. -J., Münch, P., Philippon, M., the ANTITHESIS and GARANTI Scientific Team, 2021, Paleogene V-Shaped Basins and Neogene Subsidence of the Northern Lesser Antilles Forearc: Tectonics, v. 40, https://doi.org/10.1029/2020TC006524.

Bouysse, P., and Mascle, A., 1994, Sedimentary basins and petroleum plays around the French Antilles. In Hydrocarbon and Petroleum Geology of France: Springer, Berlin, Heidelberg, p. 431–443, https://doi.org/10.1007/978-3-642-78849-9_32.

Bouysse, P., Andréïeff, P., Richard, M., Baubron, J.C., and Mascle, A., 1985, Aves Swell and northern Lesser Antilles Ridge: rock-dredging results from ARCANTE 3 cruise. In: Symposium géodynamique des Caraïbes, p. 65–76, Technip Ed.

Cornée, J.-J., Münch, P., Philippon, M., BouDagher-Fadel, M., Quillévéré, F., Melinte-Dobrinescu, M., Lebrun, J.-F., Gay, A., Meyer, S., Montheil, L., Lallemand, S., Marcaillou, B., Laurencin, M., Legendre, L., Garrocq, C., Boucard, M., Beslier, M.-O., Laigle, M., Schenini, L., Fabre, P.-H., Antoine, P.-O., and Marivaux, L., 2021, Lost islands in the northern Lesser Antilles: possible milestones in the Cenozoic dispersal of terrestrial organisms between South-America and the Greater Antilles: Earth-Science Reviews, v. 217, no. 103617, https://doi.org/10.1016/j.earscirev.2021.103617.

Appendix 5 : DETAIL OF AR/AR STEP-HEATING ANALYSES

Samples were then crushed and sieved and a 200—300 µm grain size was retained for plagioclase and groundmass separation. After magnetic separation, fresh plagioclase and groundmass were selected under a binocular microscope. The grains were leached with HN03 (1N) for a few minutes and then repeatedly cleaned ultrasonically in distilled water and alcohol. Samples were packed in aluminium foil for irradiation in the core of the Triga Mark Il nuclear reactor of Pavia (Italy) with several aliquots of the Taylor Creek sanidine standard (28.619 ± 0.034 Ma in Renne et al., 2011) as flux monitor.

Argon isotopic interferences on K and Ca were determined by irradiation of KF and CaF_2 pure salts from which the following correction factors were obtained: $(^{40}Ar/^{39}Ar)_K = 0.00945 \pm 0.00077$, $(^{38}Ar/^{39}Ar)_K = 0.029500 \pm 0.0009425$, $(^{39}Ar/^{37}Ar)_{Ca}$ 0.000614 ± 0.000088 and $(^{36}Ar/^{37}Ar)_{Ca} = 0.000259 \pm 0.000017$. The gas extraction and purification line consisted of (a) an IRC02 laser of 100 kHz used at 3-20% power to heat samples for 60 seconds, (b) a lenses system for beam focusing, (c) a steel chamber maintained at 10^{-8} - 10^{-9} bar, with a copper holder in which 2 mm-diameter blind holes were milled, (d) two Zr-Al getters for purification of gases and e) a cold trap. Argon isotopes are analyzed with an Argus VI multi-collection mass spectrometer (with 4 faradays for masses ^{40}Ar–^{37}Ar and ion counting on ^{36}Ar). One minute was allowed for equilibration before analysis. Mass discrimination was monitored daily using an automated air pipette and provided a mean value of between 0.999157 ± 0.002997 and 0.998358 ± 0.002995 per dalton. Blank analyses were performed every three sample analyses. Isotopic ratios were corrected for irradiation interferences and air contamination using a mean air value $(^{40}Ar/^{36}Ar)_{atm}$ of 298.56 ± 0.31 (Lee et al., 2006).

REFERENCE CITED

Lee, S.H., Iza, F., and Lee, J.K., 2006, Particle-in-cell Monte Carlo and fluid simulations of argon-oxygen plasma: Comparisons with experiments and validations: Physics of Plasmas, v. 13, no. 5, 57102, https://doi.org/10.1063/1.2179430.