Foraminifera in the Concord Limestone Member (Brasso Formation, Early Middle Miocene) of Trinidad, Western Tropical Atlantic Ocean: a Product of Sediment Starvation Near an Oxygen Minimum Zone*

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Abstract

The foraminifera in the laterally extensive, thin limestone members of the Brasso Formation of western Central Trinidad are little known. This paper examines those in the ~80 m thick Concord Limestone Member and bounding mudstones. Of forty-five samples collected, only thirteen yielded foraminifera. Total recovery was dominated by *Uvigerina subperegrina* gr. and *Cassidulina laevigata*, which indicated the section to be deposited along the upper margin of an oxygen minimum zone. Recovery of *Cibicidoides matazasensis* throughout indicates deposition at middle to outer neritic palaeodepths. This is corroborated by palaeodepths of ~43 – 207 m computed on the basis of the percentage of assemblages as planktonic foraminifera (but excluding low-oxygen stress indicators and allochthonous shoal-water species derived from a carbonate factory). A decline in the percentage abundance of *U. subperegrina* gr. through the section indicates that the flux of organic carbon to the site diminished over time. The mean palaeodepth for the Concord Limestone Member (99.3 m) did not differ significantly from that of the overlying mudstones (79.4 m), suggesting that the carbonate developed as a result of a period of sediment starvation unrelated to changes in palaeodepth. Sample spacing was too wide, however, to discern transgressive-regressive cycles in detail. The mean palaeodepth for the Concord Limestone member exceeded maximum palaeodepths of 55 m computed for the Mayo Limestone Member, which lacked specimens of the deeper water species recovered from the Concord Limestone. This suggests that a single palaeoenvironmental model cannot be applied to all limestone members within the Brasso Formation.

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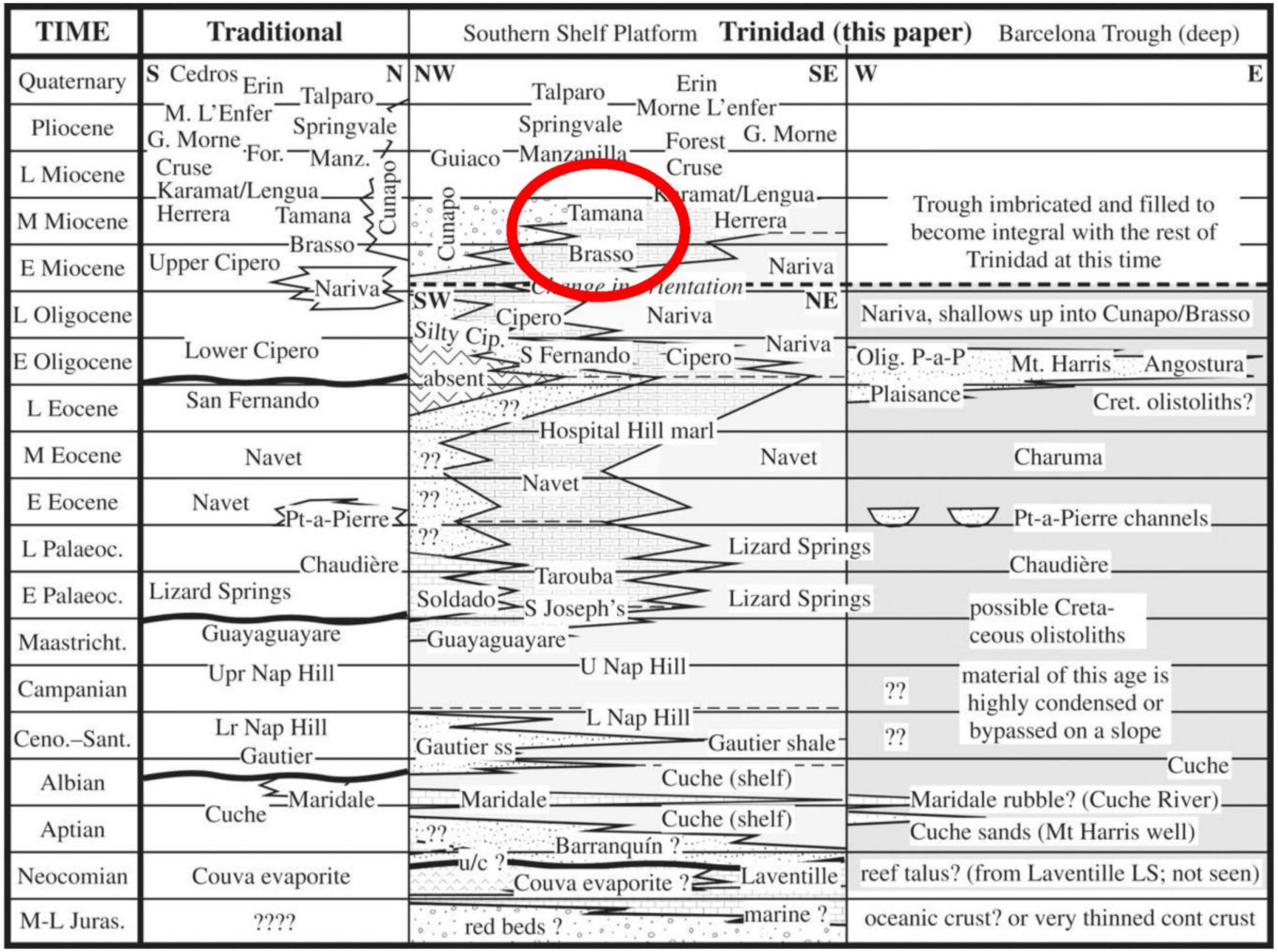
Stratigraphy of Trinidad



Presenter's notes: Part of a wider problem regarding the validity or not of the Tamana Formation as separate from and overlying the Brasso Formation

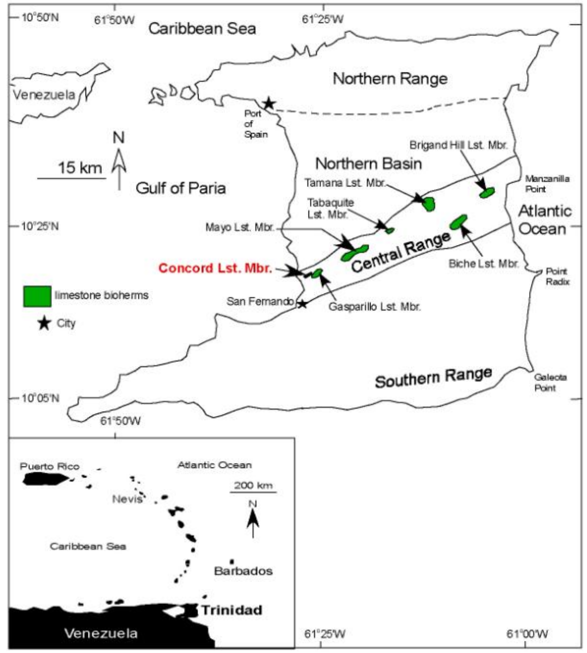
The Brasso Formation

- Early to Middle Miocene (*Globigerinatella insueta* through *Globorotalia fohsi robusta* planktonic foraminiferal zones [N7-N12 of Blow, 1969])
- ~12.4-18 million years old
- Possibly older locally (*Catapsydrax dissimilis* Zone (N5—20.5 million years old)

Age		Planktonic Foraminiferal Zones	Approx. N Zone equivalents	Age at base (millions of years, approximate)
Miocene	Middle	*Globorotalia fohsi robusta*	N12	13.9
		Globorotalia fohsi lobata	N11	14.7
		Globorotalia fohsi fohsi	N10	15.3
		Globorotalia fohsi peripheroronda	N9	16
	Early	*Praeorbulina glomerosa*	N8	17.2
		Globigerinatella insueta	N7	18
		Catapsydrax stainforthi	N6	18.6
		Catapsydrax dissimilis	N5	20.5

Presenter's notes: Brasso Formation extends from *Catapsydrax dissmilis* to Globorotalia fohsi robusta Zones (N5-N12). Tamana placed in *Globorotalia mayeri* Zone N14 (Kugler, 2001). Not sure where N13 is.

Trinidad and the Middle Miocene Carbonates



Limestones suggested by Kugler to be of N14 age (Tamana Formation)

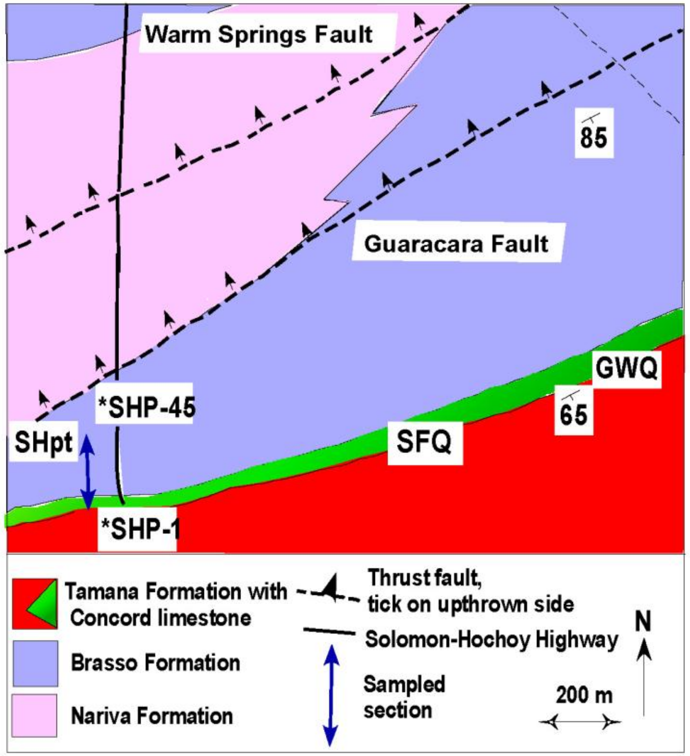
Concord Limestone Member in red

Research Question: were all the mid Miocene limestones deposited in the same palaeoenvironment?

Presenter's notes: The Tamana was erected to cover a series of limestone bioherms and enclosing sediment. Bioherms are oval in plan view. Some more laterally extensive but thin limestones in the Tamana Formation. The Concord Limestone Member can be traced for ~2.8 km between Gasparillo Quarry and the No. 5 Reservoir at the Pointe-a-Pierre oil refinery compound.

These bioherms, each of which Wilson elevated to member status within the Brasso Formation, were most prolifically developed during the mid Middle Miocene *Globorotalia fohsi fohsi* planktonic foraminiferal Zone of Bolli (1957) (= Zone N10 of Blow, 1969).

Geological map of the Concord Limestone



Map after Kugler (1996)

(Kugler 1996):

- Concord Limestone inverted, dipping south but younging north
- Northern (younger) edge of Concord Limestone is an unconformity against (older) Brasso
- **This does not make sense**
- Will here compare bulk environment of Concord Limestone with underlying Brasso Formation

Presenter's notes: In April 1998, a north-south trench was excavated for a gas pipeline parallel to the Solomon-Hochoy Highway that traversed the Concord Limestone Member and intersected some of the Brasso Formation mudstones to the north and south.

Foraminifera (for those who have forgotten)

•Single celled bugs <1 mm

•Planktonic (float near sea surface)

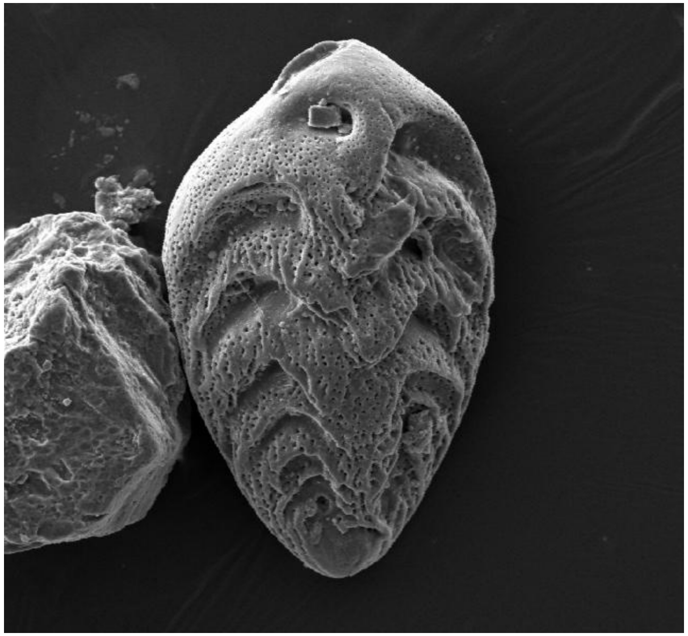
•Benthic (live on seafloor)

•Shelled

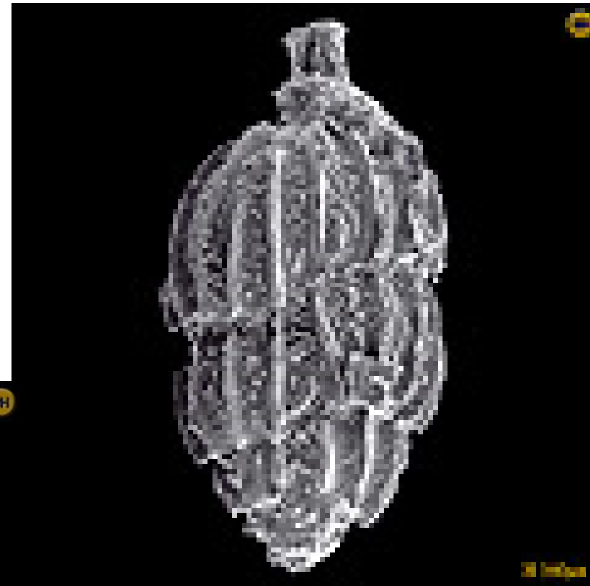
•Narrow ecological niches

•Abundant in marine environments

•Beautiful

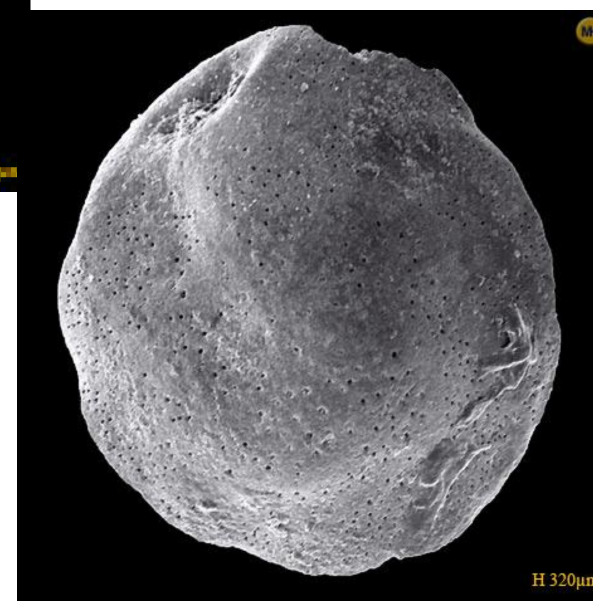


Foraminifera to remember for the next twenty minutes

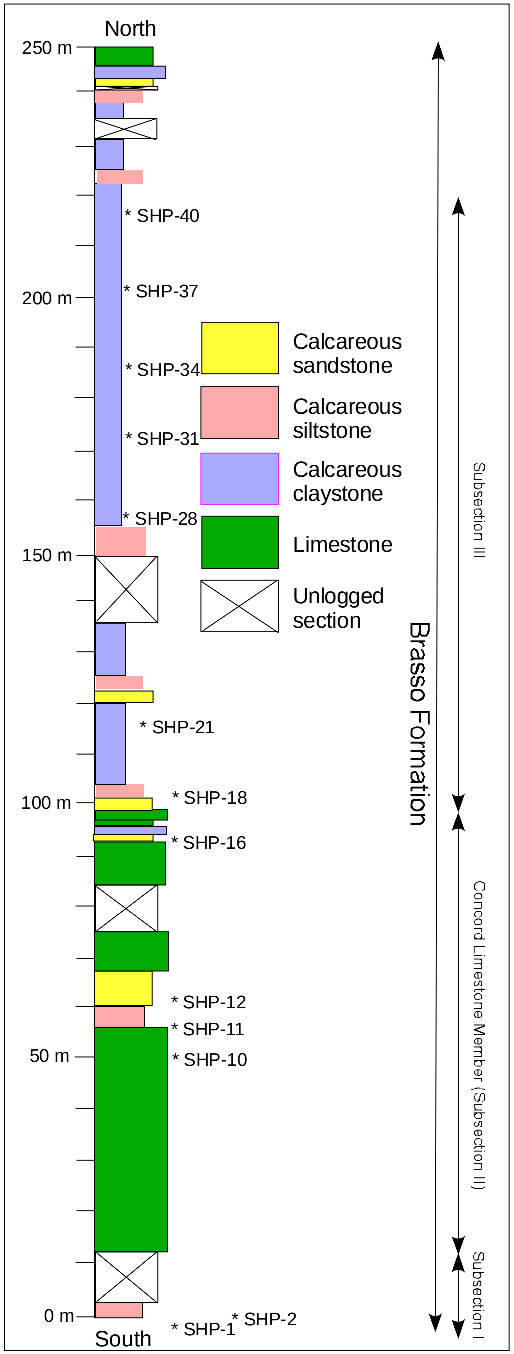


Uvigerina ex gr. *subperegrina* Cushman and Kleinpell

Bolivina jiattongae Wilson



Cassidulina laevigata d’Orbigny



Sedimentological log (from south to north)

- Forty two samples recovered for micropalaeontological study
- Only 13 (marked) yielded foraminifera
- Of these, 6 within the Concord Limestone
- Kugler (2001) suggested Concord Limestone to be part of Tamana Formation (*Globorotalia menardii* Zone, N14)
- However, Tamana Formation lateral equivalent of part of Brasso Formation (Wilson, 2012)

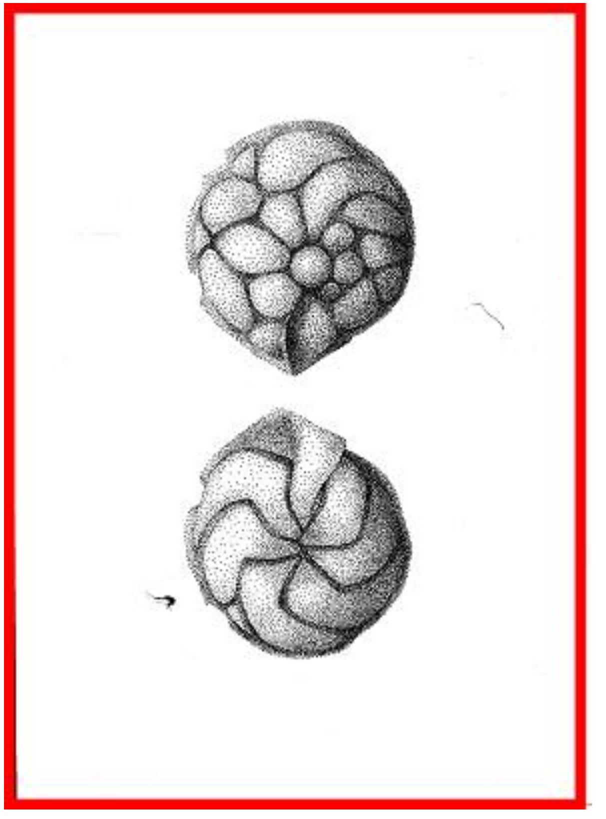
Planktonic forams and the age of Concord Limestone

Planktonic species presence/absence	SHP1	SHP2	SHP10	SHP11	SHP12	SHP16	SHP18	SHP21	SHP28	SHP31	SHP34	SHP37	SHP40
Globorotalia fohsi peripheroacuta	-	*	*	*	*	-	*	*	*	*	*	*	-
Globorotalia fohsi peripheroronda	*	-	-	*	-	-	*	*	*	*	-	*	-
Globorotalia praemenardii	*	*	-	*	-	-	*	*	-	*	-	*	-
Globorotalia scitula scitula	*	*	*	*	*	*	*	*	*	*	*	*	*

- 996 planktonic foraminifera in 13 samples
- *Globorotalia scitula scitula* in all samples [age no older than the *Globorotalia fohsi fohsi* Zone (N10)] (Bolli et al., 1985)
- *Globorotalia praemenardii* between SHP-1 and SHP-37 supports N10 age
- *Globorotalia fohsi peripheroronda* and *G. fohsi peripheroacuta* between SHP-1 and SHP- 37 in conjunction with *G. scitula scitula* indicate early N10

Benthic foraminiferal fauna

- 5200 benthonic foraminifera in 91 species recovered from the 13 samples
- Total benthonic recovery was dominated by *Uvigerina subperegrina* gr. (21.0%)
- Subdominant *Cassidulina laevigata* (14.5%)
- Only three other species formed >4% of the total recovery: *Globocassidulina subglobosa* (7.9%), *Cibicidoides matanzasensis* (7.0%) and *Sigmavirgulina tortuosa* (5.3%).

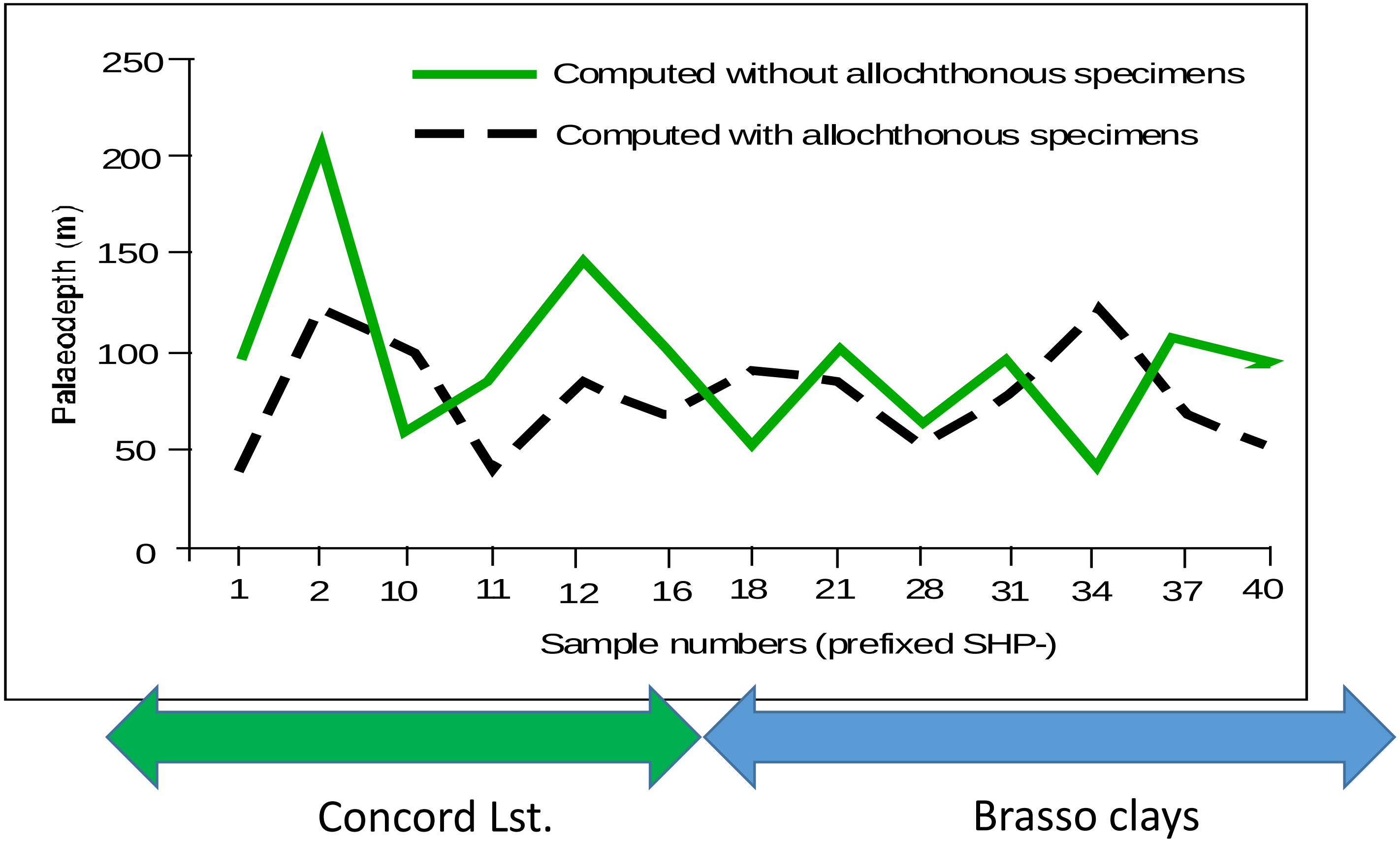


Amphistegina martybuzasi Wilson, Ramkissoon and McLean, 2011

Palaeodepth I

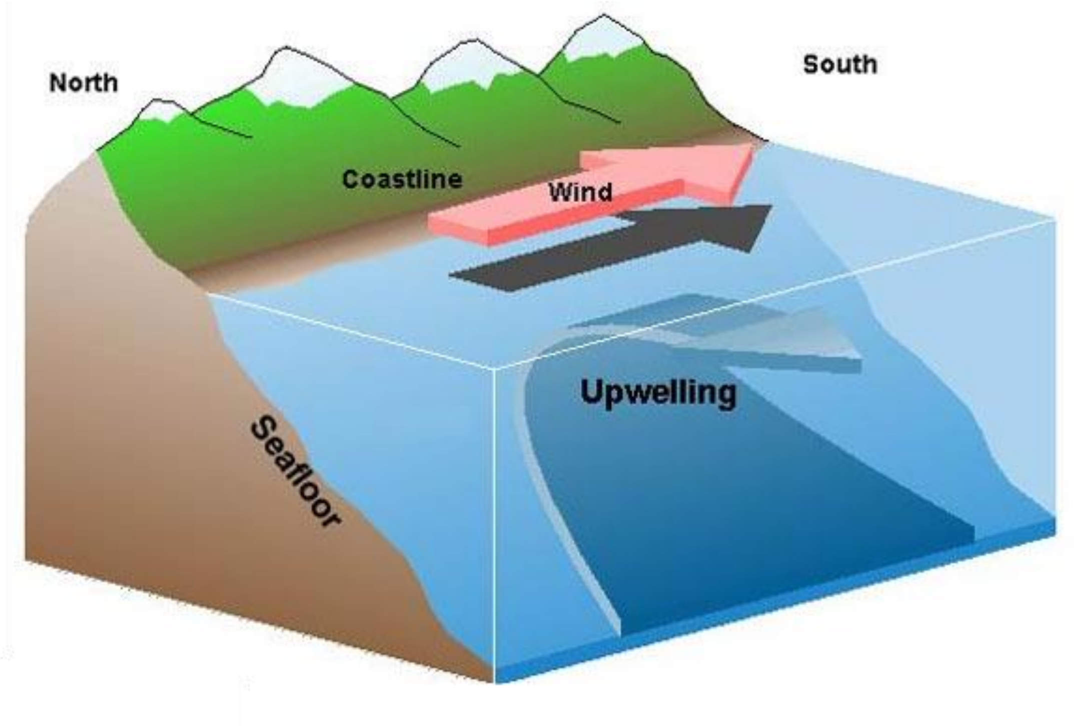
- Calculated after van Hinsbergen et al. (2005)
- The percentage of the total assemblage in each sample as planktonic foraminifera (%P) calculated from $\%P = 100*[(P/P + B - S)]$
- P = number of planktonic foraminifera, B = total number of benthonic ones, S = number of low-oxygen stress markers
- S are *Bolivina* spp., *Brizalina* spp., *Bulimina*, *Uvigerina* spp., *Valvulineria* spp., *Cancris* spp., *Fursenkoina* spp., *Globobulimina* spp. and *Chilostomella* spp.
- Depth D (in metres) is given by $D = e^{(3.58178 + 0.03534*\%P)}$

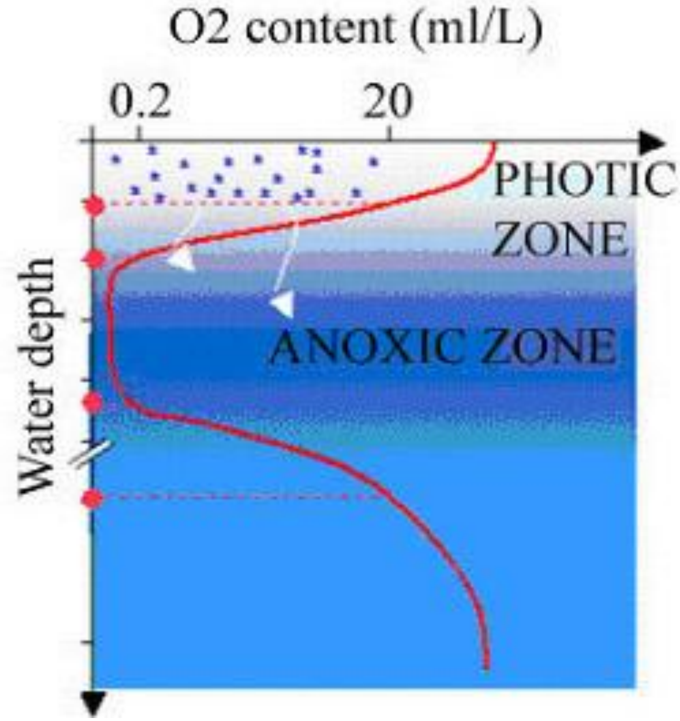
Palaeodepth II



- Values of %P with presumed allochthonous species ranged between 2.1 – 35.0%
- Equates to palaeodepths of ~39 – 124 m (mean, 77 m, sd = 26 m)
- No significant change in depth between Concord Limestone and Brasso – sediment starvation?

Upwelling and oxygen minimum zones (OMZs)

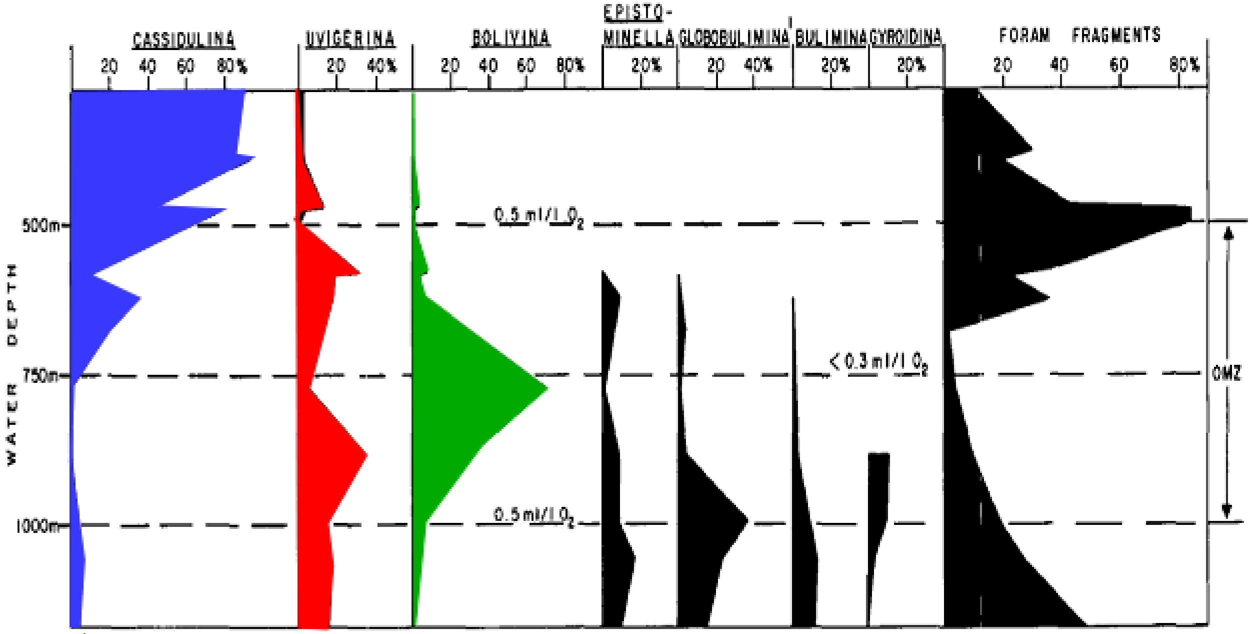


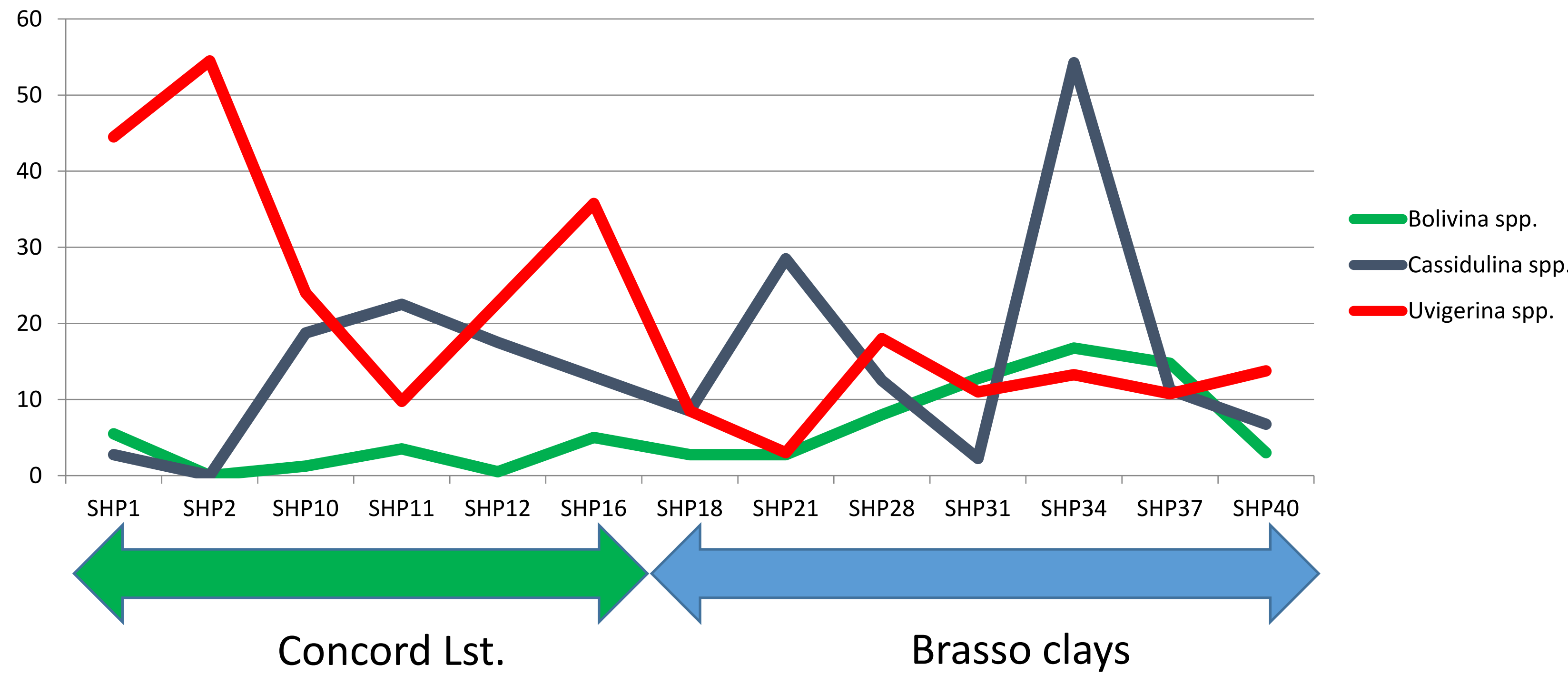


http://earthguide.ucsd.edu/virtualmuseum/images/OceanicOxygenProfile.html

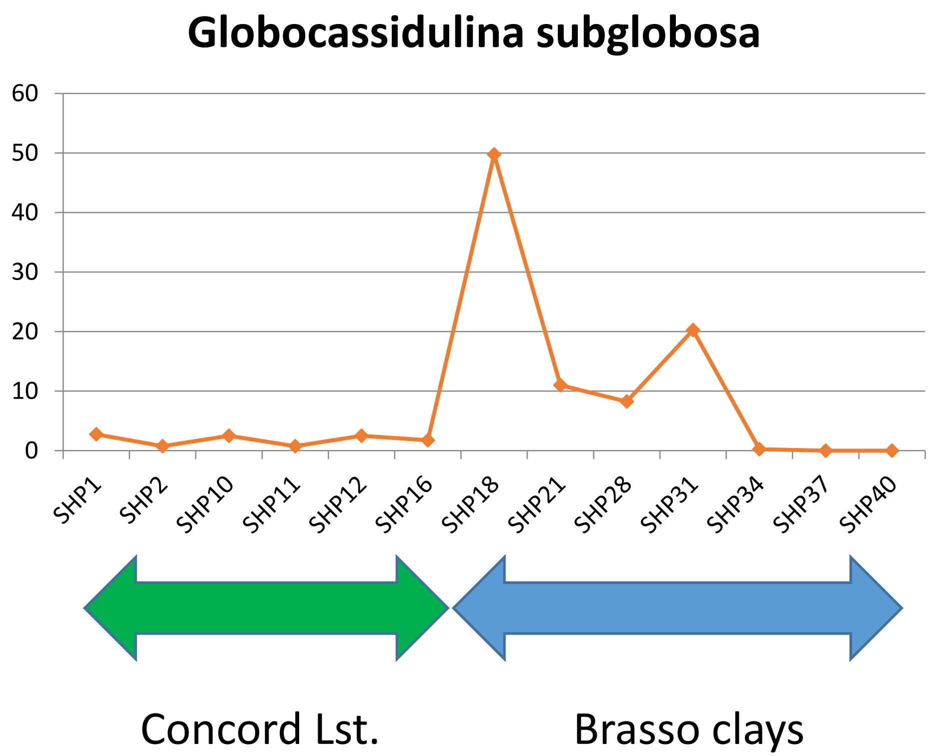
http://www.greenseaupwelling.com/_images/upwellPic.png

OMZ effects


CASSIDULINA
20 40 60 80%
UVIGERINA
20 40%
BOLIVINA
20 40 60 80%
EPISTO-MINELLA
20%
GLOBOBULIMINA
20 40%
BULIMINA
20%
GYROIDINA
20%
FORAM FRAGMENTS
20 40 60 80%
WATER DEPTH
500m
750m
1000m
0.5 ml/l O2
< 0.3 ml/l O2
0.5 ml/l O2
OMZ


60
50
40
30
20
10
0
SHP1
SHP2
SHP10
SHP11
SHP12
SHP16
SHP18
SHP21
SHP28
SHP31
SHP34
SHP37
SHP40
Bolivina spp.
Cassidulina spp.
Uvigerina spp.
Concord Lst.
Brasso clays

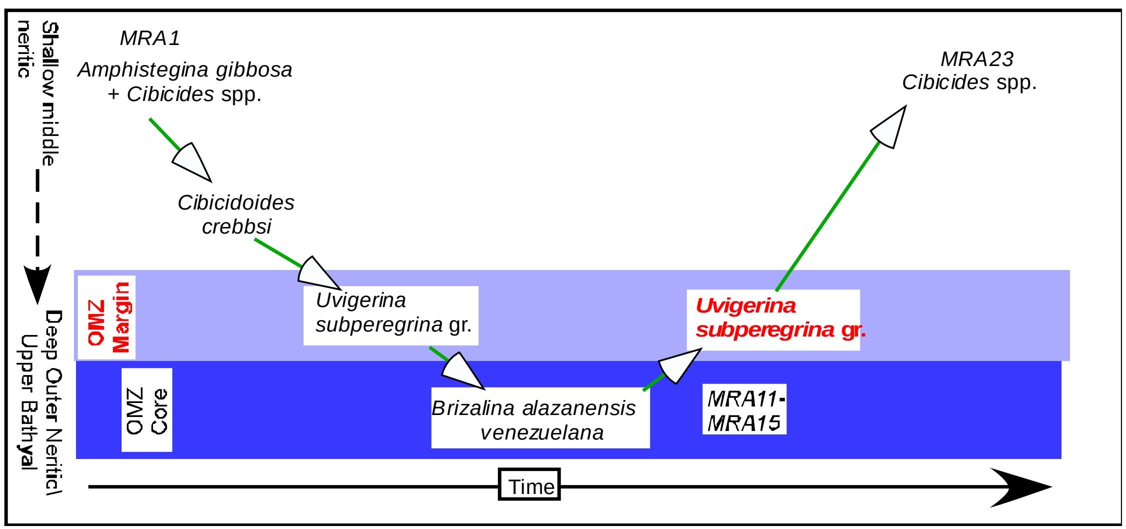
Seasonal Upwelling

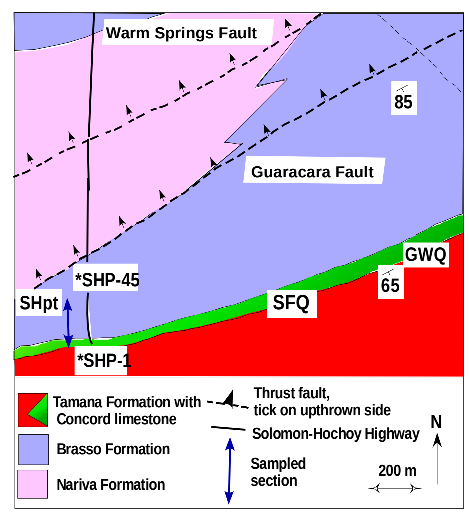


- *Globocassidulina subglobosa* is an indicator of a seasonal, pulsed phytodetrital input (Gooday, 2002).
- This may reflect the impact of seasonal upwelling

Comparison I: The Upper Concord Silt at Gasparillo Quarry, western central Trinidad

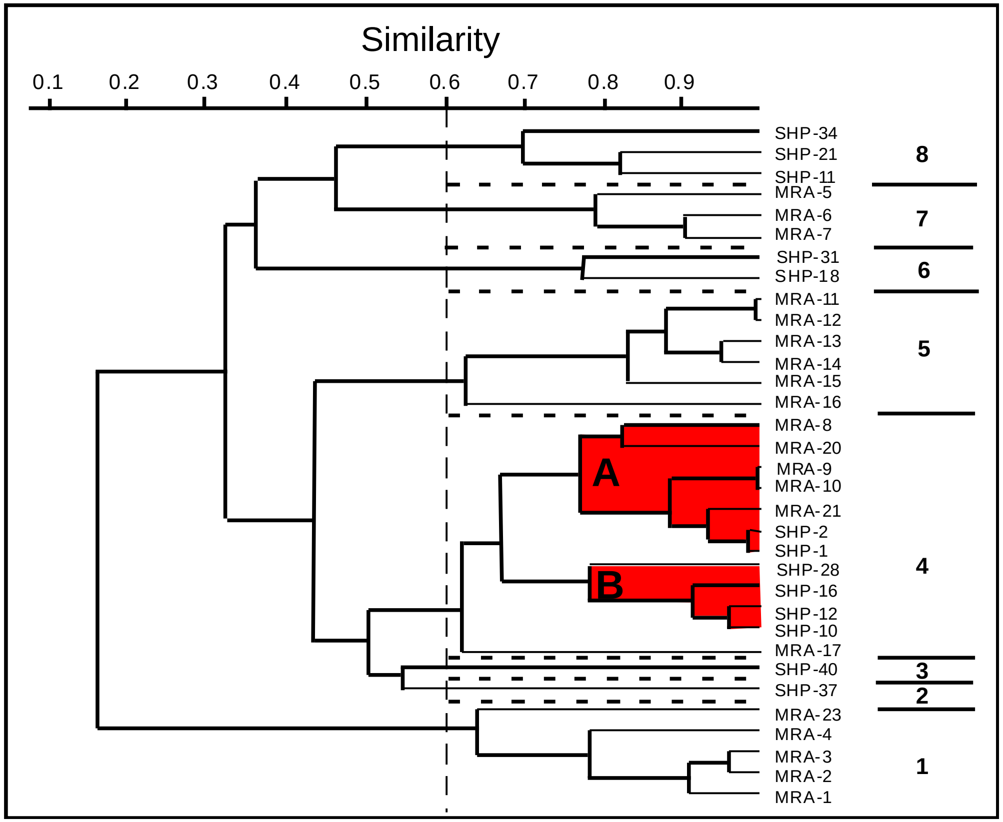
- 24 m section sampled every 1 m in the Gasparillo West Quarry
- Samples prefixed MRA
- Planktonic foraminiferal Zones N8-N10
- Transgressive-regressive cycle and OMZ, margin dominated by *U. subperegrina*.
- Maximum palaeodepth ~215 m, within OMZ (*Brizalina* dominant).





Comparison I, continued

- Amalgamated Solomon Hochoy Highway pipeline (SHP) and Gasparillo Quarry West clay/silt samples were subjected to cluster analysis.



- **Samples from Concord Limestone group with those from OMZ margin from Gasparillo Quarry West**
- **SHP Brasso samples correlate with Gasparillo samples above OMZ**

Comparison II: the Guaracara Limestone

- Guaracara Limestone Member of Brasso Formation contains some limestone-marl couplets (Wilson et al., 2010)
- Foraminifera recovered from marls
- Benthic fauna dominated by *Cibicides* sp. 1 (15%), *Pseudononion atlanticum* (14%), *Amphistegina martybuzasi* (10.5%), *Reussella glabrata* (9.5%), *Elphidium poeyanum* (8.9%)
- No significant *Uvigerina subperegrina*, *Cassidulina laevigata, Bolivina* spp.
- Guaracara Limestone mean palaeodepth 55 m

- **Guaracara Limestone fauna indicative of a shallower palaeodepth than Concord Limestone**

Conclusions

- Concord Limestone of N10, not N14, age
- Contains fauna with many *Cassidulina laevigata*
- Associated Brasso Formation contains many *Uvigerina subperegrina* and *Bolivina* spp.
- This assemblage is indicative of proximity to upper edge of oxygen minimum zone (OMZ)
- Concord Limestone at shallow shelfal depths (mean, 77 m)
- *Globocassidulina subglobosa* in Brasso indicative of pulsed phytodetrital matter (seasonal upwelling?)
- Limestone developed due to sediment starvation
- Guaracara Limestone in shallower palaeoenvironment (mean depth, 55 m)
- Guaracara Limestone not associated with upwelling fauna

Answer to the research question

One depositional model does not fit all Brasso Formation limestones

☺

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Questions?