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The biostratigraphic and palaeoenvironmental significance of foraminifera in the Middle Miocene Upper Concord Calcareous Silt Member (Tamana Formation) near Gasparillo West Quarry, central Trinidad

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The Tamana Formation has previously been suggested to have been deposited in the Middle Miocene *Globorotalia mayeri* planktonic foraminiferal Zone (N14) and to succeed the Brasso Formation. A 24 m section of the Upper Concord Calcareous Silt Member of the Tamana Formation was sampled every 1 m in the Gasparillo West Quarry, western central Trinidad, straddling the Early to Middle Miocene boundary (*Praeorbulina glomerosa* to *Globorotalia fohsi fohsi* planktonic foraminiferal Zones [N8-N10]). Abundant benthonic foraminiferal species reveal a transgressive-regressive (T-R) cycle that brought the seafloor into contact with an oxygen minimum zone (OMZ). Middle and outer neritic rocks above the OMZ were occupied by *Amphistegina gibbosa* and *Cibicidoides crebbsi* respectively. The outer neritic to upper bathyal, upper margin of the OMZ was dominated by *Uvigerina subperegrina* gr., while *Brizalina alazanensis venezuelana* dominated the upper bathyal OMZ core. The section is correlated with the Brasso Formation at Guaico-Tamana Road. The greatest palaeodepth calculated for the T-R cycle within the Brasso Formation was ~470 m, while that for the Upper Concord Calcareous Silt was ~215 m. The difference in palaeodepth is ascribed to the Upper Concord being deposited on a pop-up structure south of the Brasso piggyback basin.

KEY WORDS: Caribbean, transgressive-regressive cycle, Brasso Formation, oxygen minimum zone, *Amphistegina*

Introduction

The southeast Caribbean island of Trinidad (latitude ~10°40'N, longitude ~61°31'W) straddles the southern boundary of the Caribbean tectonic plate (Prentice *et al.*, 2010). This has given the 4768 km^2 island a complex stratigraphic history, especially since Early Miocene times, when the southward-advancing allochthon of the Northern Range (Figure 1) first began to interact with the remainder of the island (Pindell *et al.*, 1988). Foraminiferal biostratigraphy and palaeoecology have proven valuable tools in unravelling the island's geological history (Wilson, 2010a). From south to north, the Lower to lowest Middle Miocene rocks of Trinidad have been grouped as the Cipero, Tamana and Brasso Formations (Kugler, 1953). Much progress has been made in recent years towards understanding the depositional history of the Brasso Formation, which was deposited south of the advancing allochthon in a piggy-back basin (*sensu* Ori & Friend, 1984) that is now the island's Northern Basin. As in nearby Venezuela (Smith *et al.*, 2010), Wilson (2010a and references therein) used foraminiferal palaeoecology to determine palaeodepth curves for the Brasso Formation. These showed that during the *Globigerinatella insueta* through *Globorotalia fohsi robusta* planktonic foraminiferal Zones of Bolli (1957) (=late Zones N8 through N12 of Blow, 1969) the Northern Basin was subject to two tectonically-induced transgressive-regressive (T-R) cycles. These T-R cycles repeatedly brought the seafloor into contact with a layer of seawater containing little dissolved oxygen (an oxygen minimum zone or OMZ), the core of which was shown by Wilson (2004, 2007) to be occupied primarily by *Brizalina* spp. [especially *B. alazanensis* (Cushman, 1926)] and the margins by *Uvigerina* spp. The OMZ's upper margin was occupied by *Uvigerina subperegrina* Cushman & Kleinpell, 1934, the lower by *Uvigerina carapitana* Hedberg, 1937.

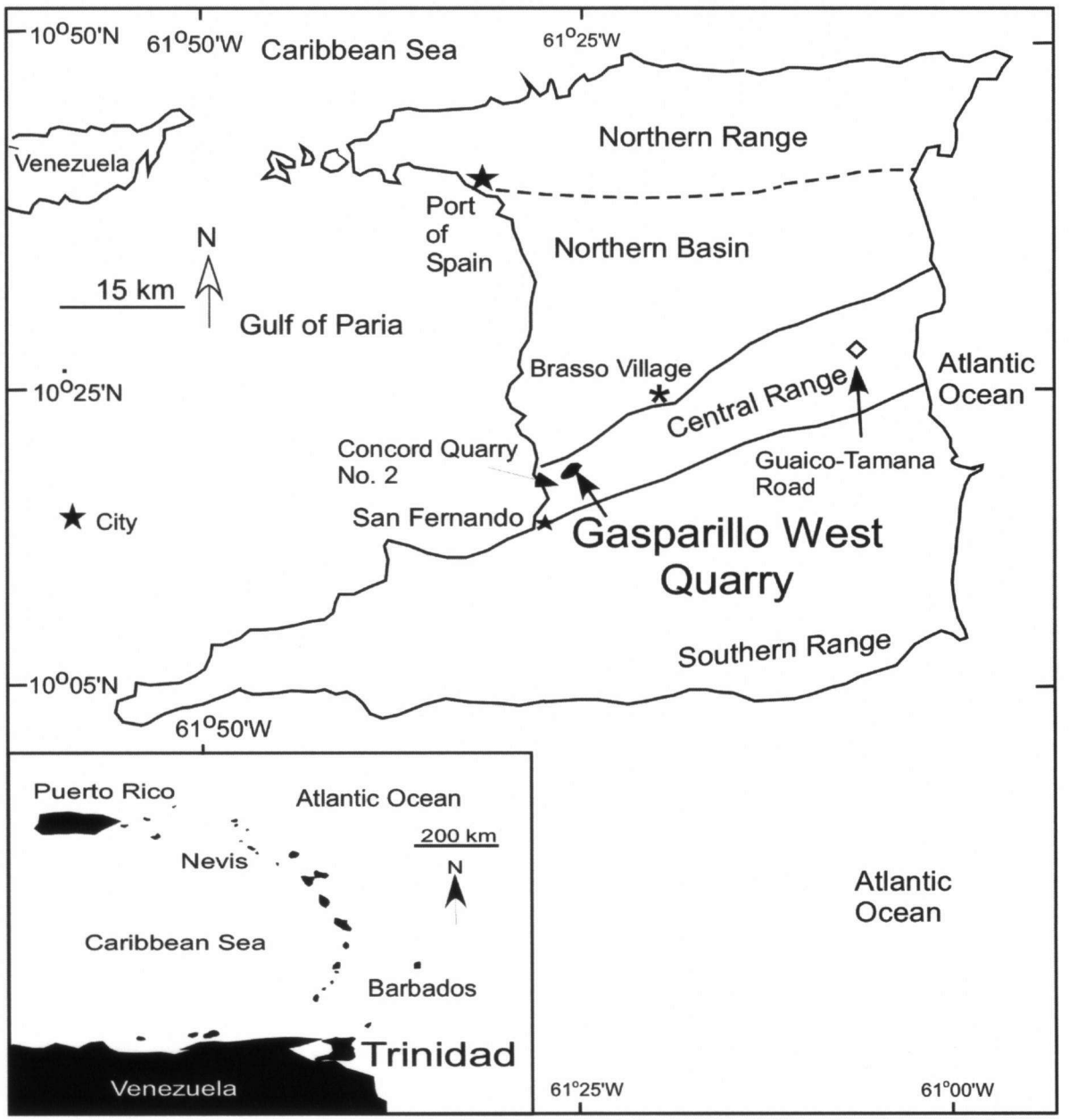

Figure 1. Trinidad, showing the locations of the Guaico-Tamana Road and Brasso Village outcrops of the Brasso Formation, and the location of the study section at Gasparillo West Quarry.

Wilson (2008a) suggested that the OMZ was formed when upwelling of cool, nutrient-rich water induced high primary productivity in surface waters. Such a process is still in operation in the SE Caribbean region (Tedesco & Thunell, 2003). Wilson (2005) hypothesised that a high abundance of *Globigerina praebulloides* Blow (1959) in the Brasso Formation was associated with this upwelling, this species in Middle Miocene times being rare elsewhere in the tropics (Kennett *et al.*, 1985). The associated Tamana Formation, however, remains relatively unstudied, as does the *Globigerina* ooze of the Cipero Formation (but see Wilson, 2008b; Pearson & Wade, 2009).

The Tamana Formation was suggested by Kugler (1953, 1956) to be a clearly defined unit that overlies the Brasso Formation and consists of four superimposed members: the Lower Concord Calcareous Silt, the Guaracara Limestone (a laterally discontinuous series of bioherms deposited on upstanding cays), the Upper Concord Calcareous Silt and the Los Atajos Conglomerate. He later (Kugler, 2001b) suggested that both the Lower and Upper Concord silts were deposited during the *Globorotalia mayeri* planktonic foraminiferal Zone (N14), the Upper Concord Calcareous Silt, the subject of this paper, overlying the Guaracara Limestone Member. At the type locality of both Concord

Calcareous Silt Members (Concord Quarry No. 2, 10°19'58"N; 61°26'49"W), the two silt members are lithologically indistinguishable and differentiated only on the basis of the intervening limestone. However, other workers have cast doubt on the age suggested by Kugler (2001). Erlich *et al.* (1993) found the bioherms of the Guaracara Limestone span the *Praeorbulina glomerosa* through *Globorotalia fohsi robusta* Zones of Bolli (1957) (Zones N8–N12 of Blow, 1969), which was confirmed by Wilson *et al.*'s (2010) finding that the bulk of the Guaracara Limestone bioherm at Mayo Quarry (10°21'32"N; 61°22'02"W) was deposited during the early Middle Miocene *Globorotalia fohsi fohsi* Zone (N10 of Blow, 1969). Thus, the bulk of the limestone at Mayo Quarry was deposited at the end of the older of the T-R cycles documented in the Brasso Formation by Wilson (2003, 2007). In a further complication, Kugler (1996, map 7) mapped Guaracara Limestone as occurring both above and below the Upper Concord Calcareous Silt between Concord Quarry No. 2 and Gasparillo West Quarry (10°20'24.63"N, 61°25'05.58"W), although the development at the base comprised small bioherms only (see Figure 2).

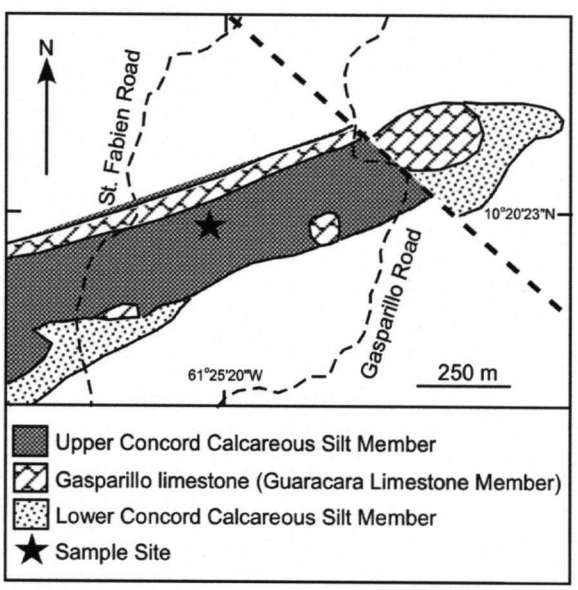

Figure 2. The Gasparillo area, showing the location of the study section.

Kugler (2001b, p. 262) also wrote that "Where the normal sedimentation of the neritic Brasso environment was normally followed by calcareous silt of almost the same aspect, the two formations [the Brasso and the Tamana] can be separated on account of their faunal differences." The North American Commission on Stratigraphic Nomenclature (2005, article 24) clearly defines a formation as a lithostratigraphic body of rock "identified by lithic characteristics and stratigraphic position," and states that a unit "distinguishable only by the taxonomy of its fossils is not a lithostratigraphic but a biostratigraphic unit."

Kugler (2001b) notes that Concord Quarry No. 2, the type locality of both Concord Calcareous Silt Members, is now abandoned and partly submerged in a reservoir. What remains is heavily overgrown. This paper documents the biostratigraphic and palaeoenvironmental significance of the foraminiferal fauna at the western end of Gasparillo West Quarry, western Central Trinidad (Figure 2), which lies on strike with Concord Quarry No. 2 and was suggested by Kugler (1996, Map 7) to expose the Upper Concord Calcareous Silt Member. It compares the assemblages at this location with those in the Brasso Formation and uses them to determine the geological age of, and palaeoenvironmental trends within, the Upper Concord Calcareous Silt at Gasparillo West Quarry.

Materials and methods

Twenty-four samples, numbered MRA1 (oldest) to MRA24 (youngest), were collected from the Upper Concord Calcareous Silt member where it crops out in the northern face at the western end of Gasparillo West Quarry, western Central Trinidad (10°20'22"N; 61°25'21"W; Figure 2). Samples were taken at 1m intervals. After soaking in water until disaggregated, they were washed over a 63μm mesh to remove silt and clay, then air dried. The >63μm fraction was picked in two stages:

1) All foraminifera were picked, whether whole or broken but including the proloculus (initial chamber), until a total of 200 planktonic specimens was reached. They were counted, identified and assigned to either the planktonic or benthonic community;
2) Further benthonic foraminifera were picked to a total of ~400 benthonic specimens, whether broken or whole.

The whole planktonic foraminifera were identified using Bolli (1957) and Bolli & Saunders (1985), while the unbroken benthonic foraminifera were identified using Bermudez (1949) and Bolli *et al.* (1995). The percentage of each sample as planktonic and benthonic specimens was calculated. The proportional abundances of the identified benthonic foraminifera were used to determine an information function H (= $-\Sigma p_i * \ln(p_i)$, where p_i is the proportional abundance of the *i*th species). The distribution of *Brizalina alazanensis venezuelana* (Hedberg, 1937), and *Uvigerina subperegrina* gr. (*U. capayana* Hedberg, 1937 + *U. subperegrina*) was examined for evidence of an oxygen minimum zone (OMZ).

The presence of a regional OMZ in Miocene times complicates attempts to construct palaeodepth curves (Wilson, 2007). Cushman & Henbest (1940) noted that in the modern North Atlantic Ocean, planktonic specimens in the foraminiferal community become more abundant with water depth. Grimsdale and van Morkhoven (1955) codified this as the planktonic:benthonic (P/B) ratio. Subsequent authors, however, found that the P/B ratio does not increase linearly with depth (Haynes, 1981). This has prompted others to seek different means of determining palaeodepths.

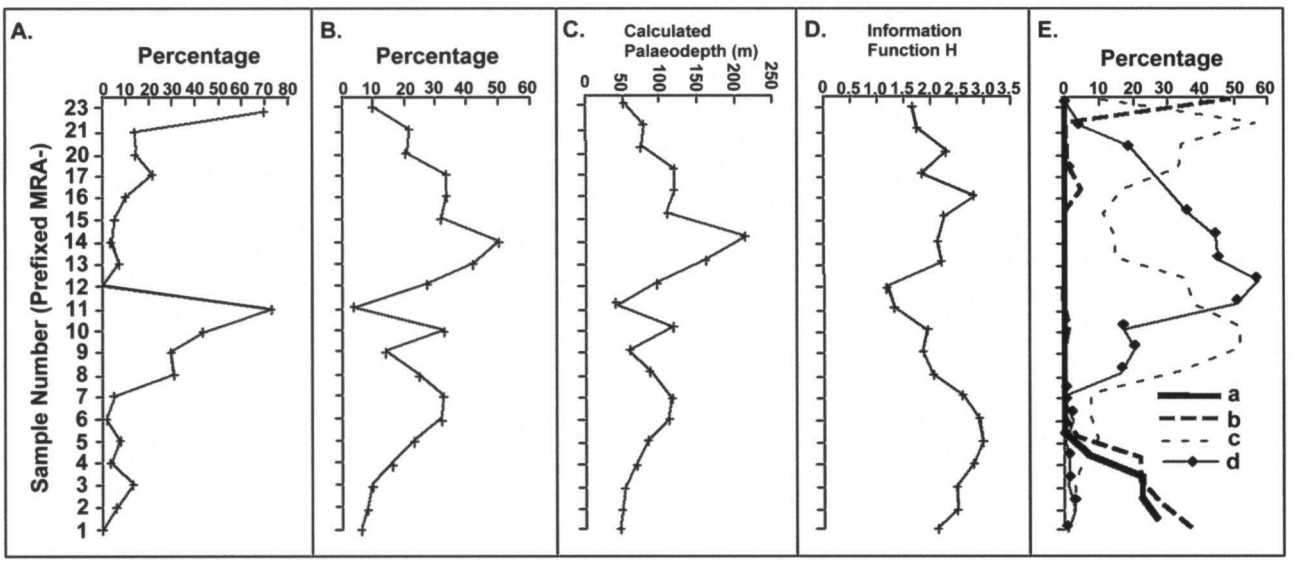

Figure 3. A. The percentage of the planktonic foraminiferal fauna as broken specimens through the Upper Concord Calcareous Silt Member. B. The percentage of the foraminiferal fauna as planktonic foraminifera, benthonic stress indicator species excluded. C. Palaeodepths in metres calculated according to the expression in van Hinsbergen *et al.* (2005). D. The information function, *H*. E. The percentage of the benthonic foraminiferal fauna as selected species: a, *Amphistegina gibbosa*; b, *Cibicides* spp.; c, *Uvigerina subperegrina* gr.; d. *Brizalina alazanensis venezuelana*.

Hayward (2004) used an analogue technique in which modern benthonic faunas around New Zealand were compared with Miocene assemblages using transfer functions and mean $\%P_t$ (percentage of the total foraminiferal fauna as planktonic specimens) calculated for each of the palaeobathymetric associations recognised. However, this technique cannot be applied to Trinidad, where census figures for the modern fauna are sparse and limited to the continental shelf (<200 m; Drooger & Kaasschieter, 1958; Wilson, 2006). Furthermore, sediment on large parts of the Trinidadian continental shelf contains a considerable relict planktonic and benthonic foraminiferal fauna of early Holocene age (Wilson, 2010b) that would have to be excluded from any modern analogue technique. Yet other authors sought exponential relationships between $\%P_t$ and depth (*e.g.*, de Rijk *et al.*, 1999). Wilson (2003) used the relationship found by de Rijk *et al.* (1999) when suggesting palaeodepths of ~60m (middle neritic) and ~470m (deep upper bathyal) for part of the Brasso Formation. Numerous studies have shown that there is a strong relationship between the dissolved oxygen concentration of bottom waters and the abundance of the benthonic foraminiferal community (see review in van Hinsbergen *et al.*, 2005), and that some genera (*Bolivina*, *Brizalina*, *Bulimina*, *Globobulimina*) are low-oxygen stress markers (Sen Gupta & Machain-Castillo, 1993; Kaiho, 1994). Stefanelli (2004) suggested that such genera typically live infaunally and are not, therefore, directly dependent on bottom water oxygenation, but on that of interstitial pore waters. Consequently, $\%P_t$ is a function not only of depth, but also of the oxygenation of the bottom and interstitial waters. Van der Zwaan *et al.* (1990) thus suggested that low-oxygen stress markers should be excluded when calculating the percentage of the fauna as planktonic foraminifera, such that $\%P = 100*[(P/P + B - S)]$, where P is the number of planktonic foraminifera, B the total number of benthonic ones, and S the number of low-oxygen stress markers. Using this technique they found a clearer relation between depth and %P such that

$$\text{Depth(m)} = e^{(3.58178 + 0.03534*\%P)} \quad (1).$$

Van Hinsbergen *et al.* (2005) expanded van der Zwaan *et al.*'s (1990) list of stress indicators to include *Bolivina* spp. (here taken to include *Brizalina* spp.), non-costate *Bulimina*, *Uvigerina* spp., *Valvulineria* spp., *Cancris* spp., *Fursenkoina* spp., *Globobulimina* spp. and *Chilostomella* spp. Van Hinsbergen *et al.*'s (2005) technique cannot resolve palaeodepths of <36 m, that being the value returned by expression (1) where %P = 0. It is nevertheless used here to estimate palaeodepths in the Upper Concord Calcareous Silt Member.

Results

Four samples from near the top of the section were barren of foraminifera. A total of 1345 planktonic and 7083 benthonic foraminifera were picked from the remaining 20 samples, of which 161 planktonic and 218 benthonic specimens were broken (*i.e.*, ~12% and ~3% of the total recovery respectively). The whole planktonic foraminifera were assigned to 34 species and the benthonic foraminifera to 96 species or species groups (Data Repositories 1 and 2). The succession may straddle the Lower to Middle Miocene boundary, here taken as coinciding with the top of the *Praeorbulina glomerosa* Zone (intra earliest N9). The occurrence of *Globorotaloides variabilis* in sample MRA1, at

the bottom of the section, indicates an age no older than the latest *Praeorbulina glomerosa* Zone (earliest N9 of Blow, 1969) while the presence of *Orbulina universa* in MRA3 suggests that the base of the earliest Middle Miocene *Globorotalia fohsi peripheroronda* Zone (N9) lies immediately above MRA2. *Globorotalia praemenardii*, *G. fohsi peripheroronda* and *G. scitula* in MRA21, near the section top, are indicative of the *Globorotalia fohsi fohsi* Zone (N10).

The percentage of the planktonic foraminiferal assemblage per sample that was broken ranged between 0% and 69%, being highest in MRA-23 (which yielded only thirteen broken and unbroken planktonic foraminifera) and MRA-10, and lowest in MRA-1 and MRA-12 (Figure 3A).

The mean percentage of broken planktonic foraminifera was 18%. The correlation between the number of planktonic foraminifera recovered from each sample and the percentage of broken specimens was not significant ($r = 0.24$, $p = 0.30$). Total planktonic foraminiferal recovery was dominated by *Globigerina praebulloides*, with subdominant *Globorotalia obesa* (Bolli, 1957) and *Cassigerinella chipolensis* (Cushman & Ponton, 1932).

Total benthonic foraminiferal recovery from the 20 samples was co-dominated by *Uvigerina subperegrina* gr. and *Brizalina alazanensis venezuelana*. The section contains a succession of benthonic foraminiferal communities (Figure 3E). The lowest sample was rich in *Cibicides* spp., *Amphistegina gibbosa* d'Orbigny, 1839 and *Amphistegina buzasi* n. sp. (see Appendix 1), but the relative abundance of all three species decreased through to sample MRA5, in which they were joined by rare *Cibicidoides crebbsi* (Hedberg, 1937). *Cassidulina carapitana* Hedberg, 1937 and *C. laevigata* d'Orbigny, 1826 collectively formed 34% of the recovery from MRA7, while the fauna was dominated by *Uvigerina subperegrina* gr. from MRA8 to MRA10. *Brizalina alazanensis venezuelana* dominated from MRA11-MRA15, in which the *U. subperegrina* gr. was subdominant. The subsequent samples MRA17 through MRA21 contained a resurgence of dominant *U. subperegrina* gr., while the uppermost MRA23 yielded abundant *Cibicides* spp. and resembled samples from the base of the section. Thus, the succession of assemblages showed a crude symmetry, samples with high abundances of *Cibicides* spp. occurring at the top and bottom and the middle consisting of samples with *U. subperegrina* gr. that bracket others with *B. alazanensis venezuelana*. The *U. subperegrina* gr. – *B. alazanensis venezuelana* – *U. subperegrina* gr. succession is concluded to indicate that at least part of the succession was deposited within an oxygen minimum zone.

The information function H (Figure 3C) for the unbroken benthonic foraminifera ranged between 1.18 (MRA-12) and 3.00 (MRA-5). It was generally low in samples rich in *U. subperegrina* gr. and *B. alazanensis venezuelana*. The percentage of the fauna as planktonic foraminifera [%P – broken specimens excluded, van Hinsbergen *et al.*'s (2004) method] ranged from ~4.5% to 51% in MRA-1 and MRA-14 respectively (Figure 3B), which from equation (1) equates to a palaeodepth range of ~40 - 215 m (Figure 3C). Values of %P were low in samples with high percentages of *A. gibbosa* ($r = -0.56$, $p = 0.01$) and *Cibicides* spp. ($r = -0.61$, $p = 0.004$). However, some samples with abundant *U. subperegrina* gr. and *B. alazanensis venezuelana* also had low values of %P. The correlation between %P and the information function for the benthonic fauna was not significant ($r = 0.164$, $p = 0.49$).

Discussion

Planktonic foraminifera indicate that rocks assigned to the Upper Concord Calcareous Silt Member near Gasparillo West Quarry were deposited during the latest Early to early Middle Miocene *Praeorbulina glomerosa* to *Globorotalia fohsi fohsi* planktonic foraminiferal Zones of Bolli (1957, = earliest N9 to N10 of Blow, 1969).

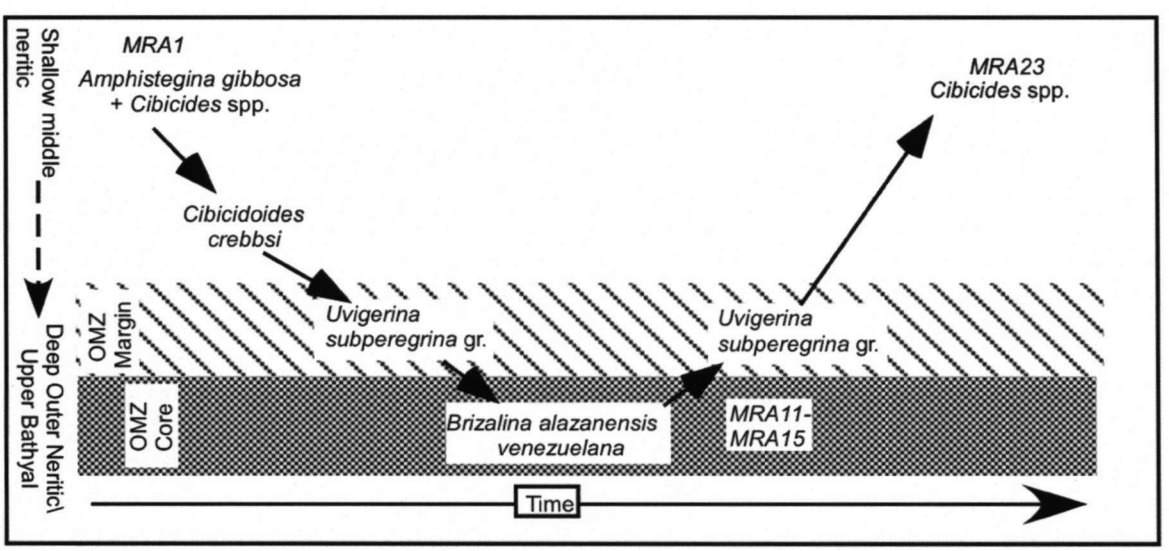

Figure 4. A palaeoenvironmental model for the Upper Concord Calcareous Silt Member, showing the trajectory of the samples taken.

This is considerably older than the *Globorotalia mayeri* Zone age (= N14) suggested by Kugler (2001). Further work is needed to ascertain if this age also applies at the type locality of the Upper Concord Calcareous Silt. The section at Gasparillo West Quarry is coeval with that part of the Brasso Formation described from along the Gauico-Tamana Road by Wilson (2003, 2004, 2010a).

Relationships with the Guaracara Limestone Member are unclear. Although Kugler (2001a) suggested that the Upper Concord Calcareous Silt succeeded the Guaracara Limestone, he (Kugler, 1996) mapped Guaracara Limestone as occurring both above and below the silt near Gasparillo West Quarry. Wilson *et al.* (2010) showed that the Guaracara Limestone at Mayo Quarry was deposited during the *Globorotalia fohsi fohsi* Zone (N10). It cannot be ascertained from foraminiferal biostratigraphy alone if the Mayo Quarry bioherm was deposited at the same time as the Upper Concord Calcareous Silt at Gasparillo West Quarry or after it. It appears, however, that limestone accumulation occurred several times throughout the deposition of the Tamana Formation, marking periods of reduced terrigenous input into the Central Trinidad area.

The progression of benthonic foraminiferal assemblages, which is broadly symmetrical around sample MRA-12, indicates the Upper Concord Calcareous Silt near Gasparillo West Quarry was deposited during a single T-R cycle (Figure 4). The genus *Amphistegina*, species of which were at the base of the Upper Concord Calcareous Silt section associated with *Cibicides* spp., is symbiotic with algae (Hallock, 1984) and lives at inner to shallow middle neritic depths (Reiss & Hottinger, 1984). The occurrence of *Cibicidoides crebbsi* between MRA-4 and MRA-8 is indicative of deep outer neritic to upper bathyal conditions (van Morkhoven *et al.*, 1986). The presence of the *U. subperegrina* gr. – *B. alazanensis venezuelana* – *U. subperegrina* gr. succession indicates that at the height of the T-R cycle the seafloor was in contact with an oxygen minimum zone (OMZ) developed as a result of oxidation of organic matter. In view of the presence of nearshore *Amphistegina* spp. at the base of the succession, species of which cannot tolerate a high flux of organic matter (Barbosa *et al.*, 2009; Hallock *et al.*, 2003), it is concluded that the organic matter responsible for the OMZ was derived from offshore primary productivity at the sea surface, not from a terrestrial source. Abundant *Cibicides* spp. in the uppermost sample indicates a return to shallow middle neritic depths at the top of the section.

Wilson (2003, 2004, 2010a), noted that the Brasso section at Guaico-Tamana Road was, like the Upper Concord Calcareous Silt near Gasparillo West Quarry, deposited during a transgressive-regressive (T-R) cycle. However, in the Brasso section the palaeobathymetric range of the T-R cycle was greater than in the Upper Concord Silt, some of the Brasso Formation being deposited along the lower margin of the OMZ. In the Upper Concord *C. crebbsi* and *Amphistegina* spp. are not found in the upper, regressive part of the succession. This may indicate that palaeoenvironmental conditions differed somewhat during the transgressive and regressive phases of the T-R cycle. A similar phenomenon was noted in the Brasso Formation at Guaico-Tamana Road, where a *Brizalina*-rich assemblage recovered from the transgressive section was not recorded from the succeeding regressive interval (Wilson, 2004).

The expression $\text{Depth(m)} = e^{(3.58178 + 0.03534 * \%P)}$, in the calculation of which benthonic foraminiferal stress indicators are excluded (van Hinsbergen *et al.*, 2005), suggests that palaeodepths ranged from ~40 - 215 m (Figure 3C) and were generally shallower at the top and bottom of the section. This confirms the occurrence of a T-R cycle. However, the pattern is not ideal, calculated depths in samples from the middle of the succession being anomalously low. This suggests that, despite the exclusion of known stress indicators when calculating palaeodepths, the OMZ had some residual effect on inferred palaeobathymetries. The maximum palaeodepth in the Upper Concord Calcareous Silt is considerably shallower than that of ~470 m inferred by Wilson (2003) for the Brasso Formation at Gauico-Tamana Road. Furthermore, as Wilson (2003) based his inference on the total benthonic foraminiferal assemblage (including stress indicators), it is possible that maximum palaeodepths for the T-R cycle in the Brasso Formation exceeded 470 m. The shallower palaeodepth for the Upper Concord Calcareous Silt apparently results from it having been deposited on a pop-up structure along the southern edge of the Brasso piggy-back basin.

Conclusions

The Upper Concord Calcareous Silt Member of the Tamana Formation at Gasparillo West Quarry was deposited during the latest Early through Middle Miocene *Praeorbulina glomerosa* to *Globorotalia fohsi fohsi* Zones (N8-N10). This is considerably older than the *Globorotalia mayeri* Zone age (N14) previously suggested and contemporary with the deposition of part of the Brasso Formation. The succession of benthonic foraminiferal associations in the Upper Concord silt is indicative of a transgressive-regressive sea level cycle that at the height of the transgression brought the seafloor in contact with an oxygen minimum zone (OMZ). The presence of abundant *Amphistegina* spp. at the base of the succession indicates that the organic matter responsible for the OMZ was derived from primary production in sea surface waters, not terrestrially derived. This T-R cycle and OMZ were recorded in the associated Brasso Formation. Thus, there appears on faunal and palaeoenvironmental grounds to be little to distinguish the Upper Concord Calcareous Silt Member of the Tamana Formation from part of the Brasso Formation. Clearly there is a need for further work to assess the validity of the Tamana Formation as a lithostratigraphically distinct body.

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APPENDIX

Class Foraminiferea J. J. Lee, 1990
Superfamily Asterigerinoidea d'Orbigny, 1839
Family Amphisteginidae Cushman, 1927
Genus *Amphistegina* d'Orbigny, 1826

Amphistegina martybuzasi n. sp.
Figure 5A-C

2010 *Amphistegina* sp. Wilson, Jones and Birjue p. 161 (list).

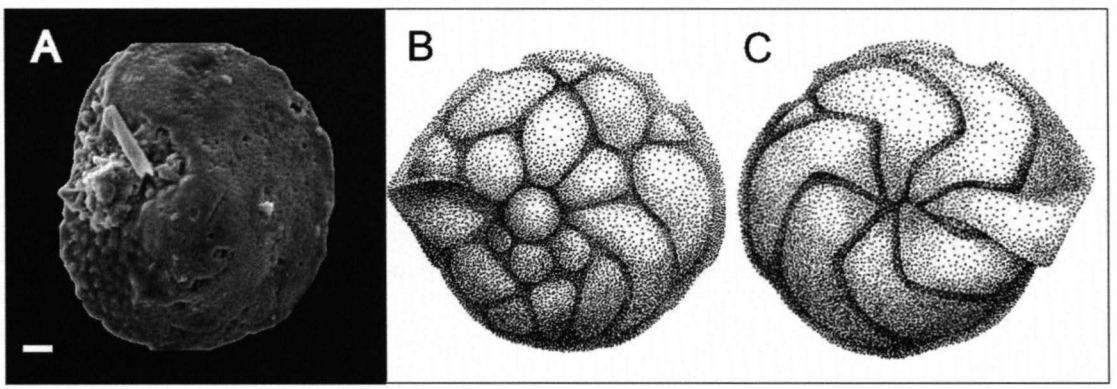

Figure 5. *Amphistegina martybuzasi* n. sp. A. SEM photomicrograph of paratype (FPXUWI-149a) showing surface details, dorsal view. Scale bar = 20 microns. B. Drawing of holotype (FPXUWI-149), dorsal view, showing internal arrangement of chambers and chamberlets. C. Drawing of holotype, umbilical view.

Diagnosis — A conical species of *Amphistegina* with a flattened attachment surface.

Description — Test free, unequally biconvex to planoconvex, conical, in two to three gradually enlarging whorls; umbilical side flat or nearly so, dorsal side more elevated reaching more or less sharp point; periphery sharp, carinate. Sutures limbate. Test involute to partially evolute on dorsal side, interior of chambers with toothplate that produces a stellate arrangement of chamberlets. Sutures on involute umbilical side with sharp dogleg at mid length. Aperture an interiomarginal slit on dorsal side, bordered by a lip; surface of preceding whorl below aperture covered with fine papillae.

Etymology — In honour of Dr Marty Buzas, Smithsonian Institution (Washington DC, USA), for his kind encouragement of Brent Wilson's work over the past two decades.

Type — The holotype (FPXUWI–149; Figures 5B, 5C) and paratype (FPXUWI-149a; Figure 5A) are located at the Petroleum Geoscience Unit, Department of Chemical Engineering, The University of the West Indies, Trinidad.

Other material — Other specimens examined are from the Upper Concord Calcareous Silt at Gasparillo West Quarry (95 specimens) and the Guaracara Limestone at Mayo Quarry (787 specimens; Wilson *et al.*, 2010), slides for which are housed in the Petroleum Geoscience Unit, Department of Chemical Engineering, The University of the West Indies, Trinidad.

Occurrence — The type locality of *A. martybuzasi* n. sp. is in the Guaracara Limestone Member of the Tamana Formation where exposed in Mayo Quarry, Central Trinidad. The outcrop exposes rocks of the *Globorotalia fohsi fohsi* planktonic foraminiferal Zone.

Stratigraphic range — *Amphistegina martybuzasi* n. sp. is known to range from the Miocene *Praeobulina glomerosa* Zone to the *Globorotalia fohsi fohsi* Zone (N8-N10).

Remarks — *Amphistegina martybuzasi* n. sp. is a homeomorph of *Asterigerina carinata* d'Orbigny, 1839. They differ,

however, in that the flat surface is in *A. martybuzasi* the ventral, umbilical surface, whereas in *A. carinata* it is the evolute, dorsal surface. Interior details do not show well in SEM photographs, so the holotype has been illustrated in a drawing. Unlike in *A. carinata*, the stellate chamberlets do not extend as far as the periphery.

Tables showing the detailed distribution of both planktonic and benthonic foraminifera in the Upper Concord Calcareous Silt Member of the Tamana Formation, Gasparillo West Quarry have been lodged with the publishers of Cainozoic Research and are available on request.