FORAMINIFERAL SEQUENCE
in
BRIDGEWATER BAY # 1,
OTWAY BASIN.

for: PHILLIPS AUSTRALIAN OIL COMPANY,

February 16th, 1984.

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Sample Depths (m)	*AGE*	*ZONE or STAGE*	*E-log Pick*	*Paleo-environment*
550 to 815	MID PLIOCENE	Zone A-3		Mid continental shelf (≈100m)* calcarenite with canyon fills at 650 & 550m
			822	
825 to 850	MID MIOCENE	Zone C		Mid continental shelf (≈100m)* biogenic calcarenite.
			860	
887	MID/LATE EOCENE	? Zone N		Inner continental shelf (≈40m)* biogenic carbonate.
			900	
934 to 1210	EARLY TERTIARY	???		Marginal Marine qtz. sands & silts with *Pebble Point Fm.* equivalent at 1210
?1244 to 2855	LATE CRETACEOUS	???		Marginal Marine qtz. sands & silts in proximity of barrier-dune system.
2895 to 3615	MID CRETACEOUS	?Mid-early Turonian ? (refer Fig.2)		Marginal Marine.
3625 to 4165	MID CRETACEOUS	???		Marginal Marine.

~~~~ = hiatus * paleobathymetric estimate

FIGURE 1: SUMMARY of BIOSTRATIGRAPHIC SEQUENCE - BRIDGEWATER BAY # 1.

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INTRODUCTION.

Eighty five sidewall cores were examined from BRIDGEWATER BAY # 1 between 550 and 4165m. Whilst drilling was in progress, seventeen rotary cutting samples were examined as urgent. Subsequently, eight cutting samples were examined between 2880 and 2985m in an attempt to clarify the discrepancy between the foraminiferal biostratigraphy and the palyno-stratigraphy of the mid Cretaceous sequence between 2895 and 3615m (refer Figure 2 - next page).

The following Figures accompany this report -

FIGURE 1 : SUMMARY of BIOSTRATIGRAPHIC SEQUENCE : on page 1.

FIGURE 2 : DISCREPANCIES in CRETACEOUS STAGE DETERMINATIONS : on page 3.

FIGURE 3 : TERTIARY to LATE CRETACEOUS FORAMINIFERAL and SEDIMENT GRAIN DISTRIBUTION : interval between 550 and 1593m.

FIGURE 4 : LATE CRETACEOUS FORAMINIFERAL and SEDIMENT GRAIN DISTRIBUTION : interval between 1613 and 2860m.

FIGURE 5 : MID CRETACEOUS FORAMINIFERAL and SEDIMENT GRAIN DISTRIBUTION : interval between 2890 and 4165m.

? MID CRETACEOUS ? - 4165 to 3625m.

Apart from contaminated cutting samples and single fragment of a *Dorothia* in the sidewall core at 3720m, no Cretaceous foraminifera were found in this interval; either in sidewall cores or cuttings.

The palynological results for this interval are inconclusive because of extremely poor preservation (see report by Helene Martin). However, many of the dinoflagellate species determined have mid Cretaceous ranges.

A dominance of quartz sand in residues at, and below, 4008m (refer Figure 5) is the only evidence for designation of the *WARRE FORMATION*. Above 4008m, and as high as 3660m, the sediment was mainly of silt grade, suggesting it represents an equivalent of the lower part of the *BELFAST MUDSTONE*.

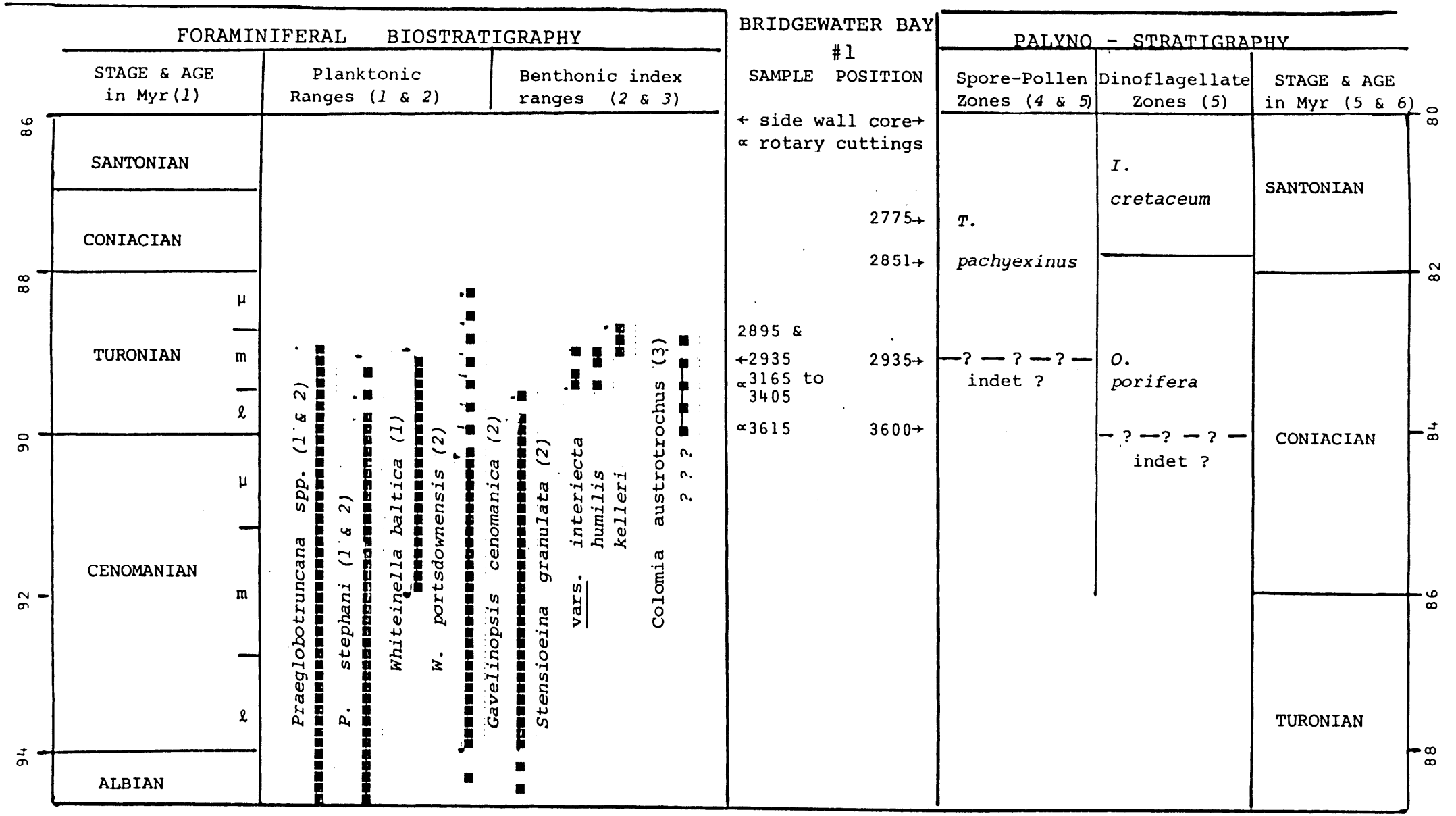

FIGURE 2: DISCREPANCIES in CRETACEOUS STAGE DETERMINATIONS for BRIDGEWATER BAY # 1.
(Compare this report with that by Helene Martin).

N.B. Differences in time scales between left and right.

References *(1) Robaszynski & Caron (1979)*
(2) Koch (1977)& Hilterman & Koch(1962)
(3) Taylor (1964 & subseq. obs.)
(4) Dettmann & Playford (1969)
(5) Stacey (1982)
(6) Van Hinte (1976)

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MID CRETACEOUS - ? TURONIAN ? - 3615 to 2895m.

Over this interval there is discrepancy in the age determination arrived at by foraminiferal biostratigraphic methods and that by palyno-stratigraphy. These discrepancies are illustrated on Figure 2 (preceeding page). It should be noted that the controversy even extends to the geochronic time scale applied on each side of the diagram. The time scale, linked with with planktonic foraminiferal correlation, is that arrived at by the European Working Group of the IGCP - Mid Cretaceous Event Project (as outlined in Robaszynski & Caron, 1979). The time scale applied by Stacey (1982) was an earlier version (Van Hinte, 1976).

The base and top of this interval is marked by the presence of the aragonitic benthonic foraminifera *Colomia austrotrochus,* which Taylor (1964) selected as an indicator of his Zonule B. Also present within this interval is one specimen of *Gavelinopsis cenomanica;* another designated Zonule B indicator.

However, of greater significance in this Bridgewater Bay interval was the presence of a few specimens of planktonic foraminifera; including a *Praeglobotruncana* sp. (SWC 2935). This specimen has strong morphological affinities to *P. stephani* (*sensu* Hiltermann & Koch, 1962 and Robaszynski & Caron, 1979) and in many ways similar to *P. delrioensis delrioensis* (*sensu* Koch, 1977, refer synonymy on p.25). Planktonics were also recorded in cuttings at 3295 and 3495m, including three specimens listed on Figure 5 as *Whiteinella baltica* (*sensu* Robaszynski & Caron, 1979), but listed also on Figure 2 as *W. portsdownensis* (*sensu* Koch, 1977).

Other occurrences of significance are four specimens of calcareous benthonic forms, representing the earliest stages of the *Stenosioeina granulata* lineage group (refer Koch, 1977, Fig. 3, p.32). The Bridgewater Bay # 1 specimens are referable to the flattened, lenticular praecursor morphotypes, rather than to the plano-convex pentultimate and ultimate forms. Thus these specimens were probably referable to either *S. granulata interiecta* or *humilis,* or possibly to the intermediate morphotype *kelleri.*

Originally, Taylor (1964) placed Zonule B within the Turonian Stage by cross-correlation of the Victorian, purely benthonic faunas, with similar faunas, associated with diagnostic planktonic forms on the Western Australian

margin. Of particular importance in this correlation was *Gavelinopsis cenomanica;* its prescribed range of Cenomanian to Early Turonian in North-Western Europe, as given by Hiltermann & Koch (1962), and confirmed in Koch (1977, Tab.1). Shell Development (1967), in their study of the Voluta # 1 sequence (in the vicinity of Bridgewater Bay # 1) applied Taylor's (1964) scheme for the Port Campbell Embayment. But for rather tenuous reasons, they amended the scheme by extending the range of *G. cenomanica* into the lower part of Zonule A. Shell Development (1967) designated this lower part of Zonule A (Zonule XA-2) as being possibly of Coniacian age, thus implying that *G. cenomanica* remained in the Otway Basin as a relict after its extinction in Western Australia and North Western Europe.

Age determinations by micropaleontologists were hampered by the total absence of biostratigraphically diagnostic, planktonic foraminiferal taxa. This problem of chrono-stratigraphic precision in a stage determination for Zonule B (of Taylor, 1964) seemed resolved by the recovery of four specimens of index planktonic forms. Even if the single specimen, listed as *Praeglobotruncana* aff. *stephani* is not referable to that species, it is indisputably a *Praeglobotruncana*, and thus the sidewall core at 2935m can be no younger than mid Turonian (refer Figure 2). The identification of *Whiteinella baltica* and/or *W. portsdownensis* strongly collaborates this conclusion. The presence of praecursor forms in the *Stensioeina granulata* lineage restricts the age of the interval, at least above 3170m, to the mid Turonian; refer Figure 2 and note from Figure 5 that *S. granulata* Group specimens were found only in cuttings. Indirect evidence regarding the range of *Colomia austrotrochus* is included on Figure 2 from Taylor's personal observations of the association of this species with early to mid Turonian planktonic foraminifera in samples from the West Australian Margin.

Admittedly, the evidence is sparse for a mid Turonian to possibly early Turonian age for the interval 3615 to 2895m; being dependant on four poorly preserved planktonic foraminifera, with supporting evidence from the presence of some ten calcareous benthonic specimens. Yet by plotting a composite of ranges of all species present, as on Figure 2, an impression emerges, albeit on sparse evidence, of a biostratigraphic placement within a narrow time span, approximating one million years.

This apparent biostratigraphic precision is exploded by the palynological determinations on the same samples (refer right hand column of Figure 2). Samples dated as *no younger* than mid Turonian on foraminiferal evidence are considered as *no older* than mid Coniacian or even early Santonian on the bulk of palynological evidence (refer palynology report on Bridgewater Bay # 1 by Helene Martin). As explained by Martin, preservation of the spore/pollen is poor within this interval and occurrence of diagnostic forms is sporadic, so the palyno-stratigraphy is dependant on dinoflagellates; particularly the zonal indicator *Odontochitina porifera* between 3600 and 2815m. Martin expresses reservations regarding the designation of these Cretaceous (as well as Tertiary) dinoflagellate zones in that there is no description or diagnoses of the zones by Stacey (1982) or his Esso Australia associates. A similar statement could be made regarding the sample locations used as evidence for the Cretaceous stage designations for the dinoflagellate zones. Such evidence is only valid if the particular dinoflagellate assemblage was associated with a stage diagnostic planktonic foraminiferal and/or ammonite fauna. As already explained, such samples are not available from the Otway Basin or elsewhere along the Southern Margin.

Possibly, the mid Turonian foraminifera were reworked in younger sediment, but it is also possible that the Coniacian/Santonian microflora were contaminants in mud penetrated sidewall cores. However, the discrepancies in Cretaceous Stage determinations for Bridgewater Bay # 1 cannot be dismissed by such argument; resolution is only possible by production of further evidence.

This interval between 3615 and 2895m was deposited in marginal marine conditions, as is evident by the predominance of arenaceous benthonic foraminifera (refer Figure 5). This Bridgewater Bay # 1 interval was deposited in even more marginal marine paleoenvironments than for the equivalent interval in Voluta # 1 between 3568.5 and 2800m, judging from the higher specific diversity and numerical specimen frequency in Voluta # 1 (Shell Development, 1967). Nondescript planktonic foraminifera, *Hedbergella*, occur fairly frequently (up to 20 specimens per sample) in the Voluta interval. The recovery of four diagnostic planktonics in the equivalent interval in Bridgewater Bay # 1 may be purely a chance factor in sampling, suggesting that they may be

present as a "trace" throughout the Basin.

LATE CRETACEOUS - 2855 to ?1244m.

This interval has been subdivided into palynological zones (both spore/pollen and dinoflagellates) by Helene Martin. No comment on the foraminiferal biostratigraphy is warranted because of the absence of diagnostic species, particularly planktonic ones.

The foraminiferal faunas, where present, were almost totally dominated by arenaceous species; particularly *Haplophragmoides* spp. The occurrence of these arenaceous assemblages were sporadic (refer Figures 3 & 4) and often were not present in samples from which Martin reports dinoflagellates. The inference is that the environment was marginal marine with strongly fluctuating conditions regarding salinity and pH. The presence of frosted and fractured quartz sand in many samples, suggests the depositional site was within the proximity of a barrier-dune system.

EARLY TERTIARY - 1210 to 934m.

Once again age determination is dependant on the palynology of Helene Martin. The sample at 1210m is of interest, as the limonitic stained, polymodal sand grains suggest correlation with the *Pebble Point Formation*. This assumption is confirmed by the presence of the dinoflagellate *Isabelidinium bakeri* in the sample at 1210m.

MID or LATE EOCENE - 887m (refer Figure 3).

This biogenic calcarenite was probably deposited at the top of the mid Eocene, although deposition of the unit (top on E-log - 860m) probably extended into the late Eocene. Deposition was on the inner continental shelf (≃40m in paleodepth).

MID MIOCENE - ZONE C - 850 to 825m.

An unconformity was apparent at 860m (E-logs) with the incoming of a distinctly (see Figure 3) mid Miocene planktonic assemblage at 850m. Deposition was on the mid continental shelf with paleodepth increasing to ≃100m.

MID PLIOCENE - ZONE A-3 - 815 to 550m.

Another unconformity was apparent at 822m (E-logs) with a mid Pliocene assemblage being recorded upwards from 815m (see Figure 3). As in the mid Miocene, deposition was on the mid continental shelf (≈100m) but there is some evidence of canyon cutting and filling with a numerical abundance of *Cassidulina leavigata* and *Fissurina* spp. at 650 and 550m. associated in richly bryozoal calcarenites. This apparent canyon activity could account for the mid Miocene/mid Pliocene unconformity at 825m. However, mid Pliocene canyon carbonate fills in Bridgewater Bay are not as well developed as those between 660 and 434m in Discovery Bay # 1.

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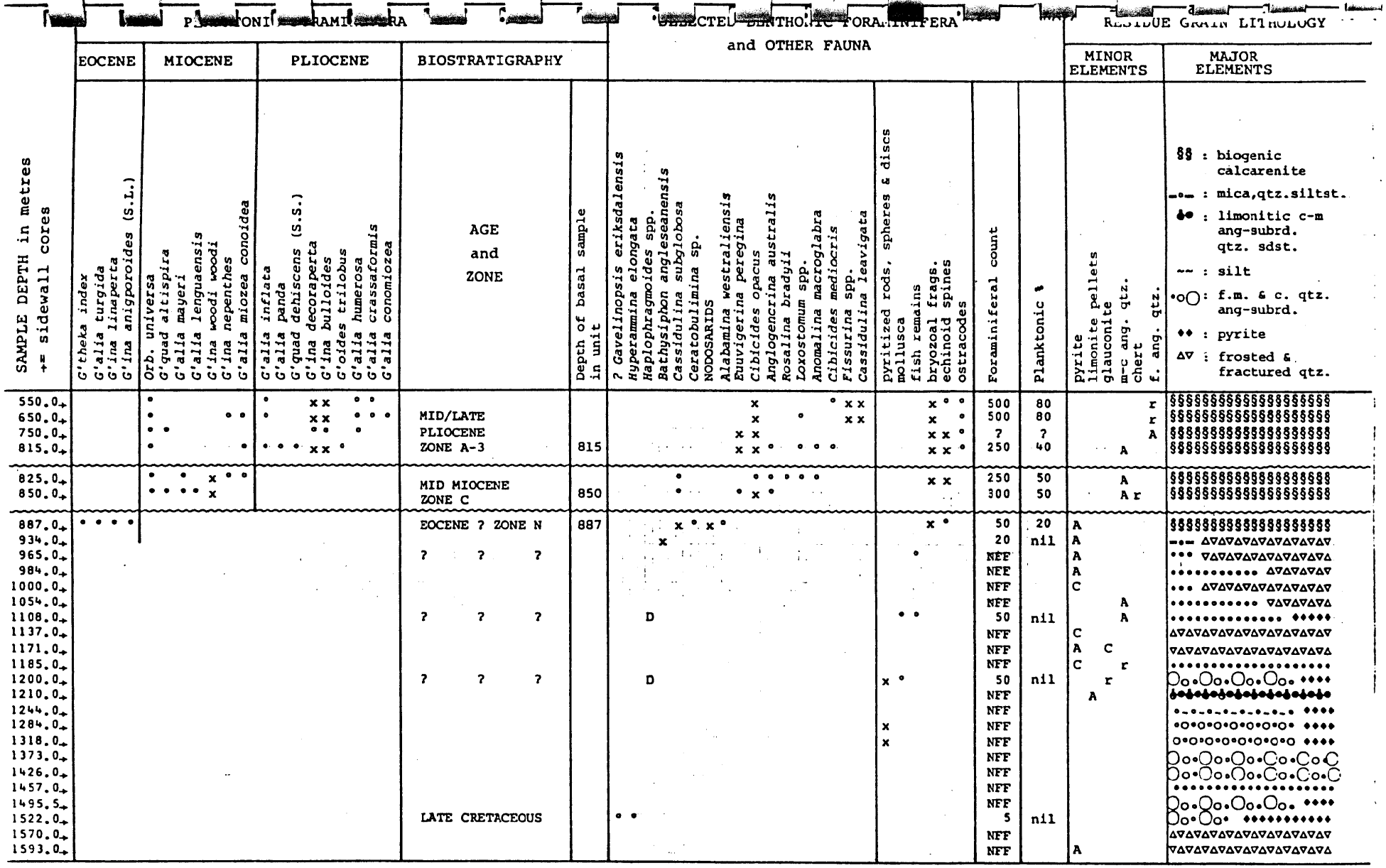

Distribution Symbol Key:

• = <20 specimens
x = >20 specimens
D = Dominant 60% specimens
N.F.F. = no foraminifera found
? = determination queried
~~~~ = hiatus
A = 1-5% grains
C = >20 grains
r = <20 grains

FIGURE 3: TERTIARY to LATE CRETACEOUS FORAMINIFERAL and SEDIMENT GRAIN DISTRIBUTION - BRIDGEWATER BAY # 1 : 550m to 1593m.

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SAM… DE… …etr… → = …dew…cor… α = rotary cuttings with base interval depths	FORAMINIFERA															OTHER FAUNA				RESIDUE GRAIN LITHOLOGY						
												STATISTICS								MINOR COMPONENTS						MAJOR COMPONENTS
	Trochammina "subinflata"	*Haplophragmoides* sp. A	*H.* sp. B	*H.* sp. C	*Ammobaculites* cf. *fragmentaria*	*Amplagena* sp.	*Bathysiphon* sp.	*Hyperammina elongata*	*Vulvulineria erugata*	*Ammodiscus* sp.	*Ammobaculites* sp.?	FORAM COUNT	% PLANKTONICS	% CALCAREOUS BENTHONICS	% ARENACEOUS BENTHONICS	pyrite spheres	pyrite rods	pyrite discs	*Inoceramus* prisms	pyrite	limonite-clay	carbonaceous matter	mica	m-c ang. qtz.	glauconite	°o: f.m. qtz. ang-subrd. △▽: frosted & fractured qtz. ~~: silt ◆◆: pyrite ♣♣: limonitic clay & pellet - siltst.& qtz. sdst.
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FIGURE 4: LATE CRETACEOUS FORAMINIFERAL and SEDIMENT GRAIN DISTRIBUTION - BRIDGEWATER BAY # 1 : 1613m to 2860m.
Refer Figure 3 for Distribution Symbols.

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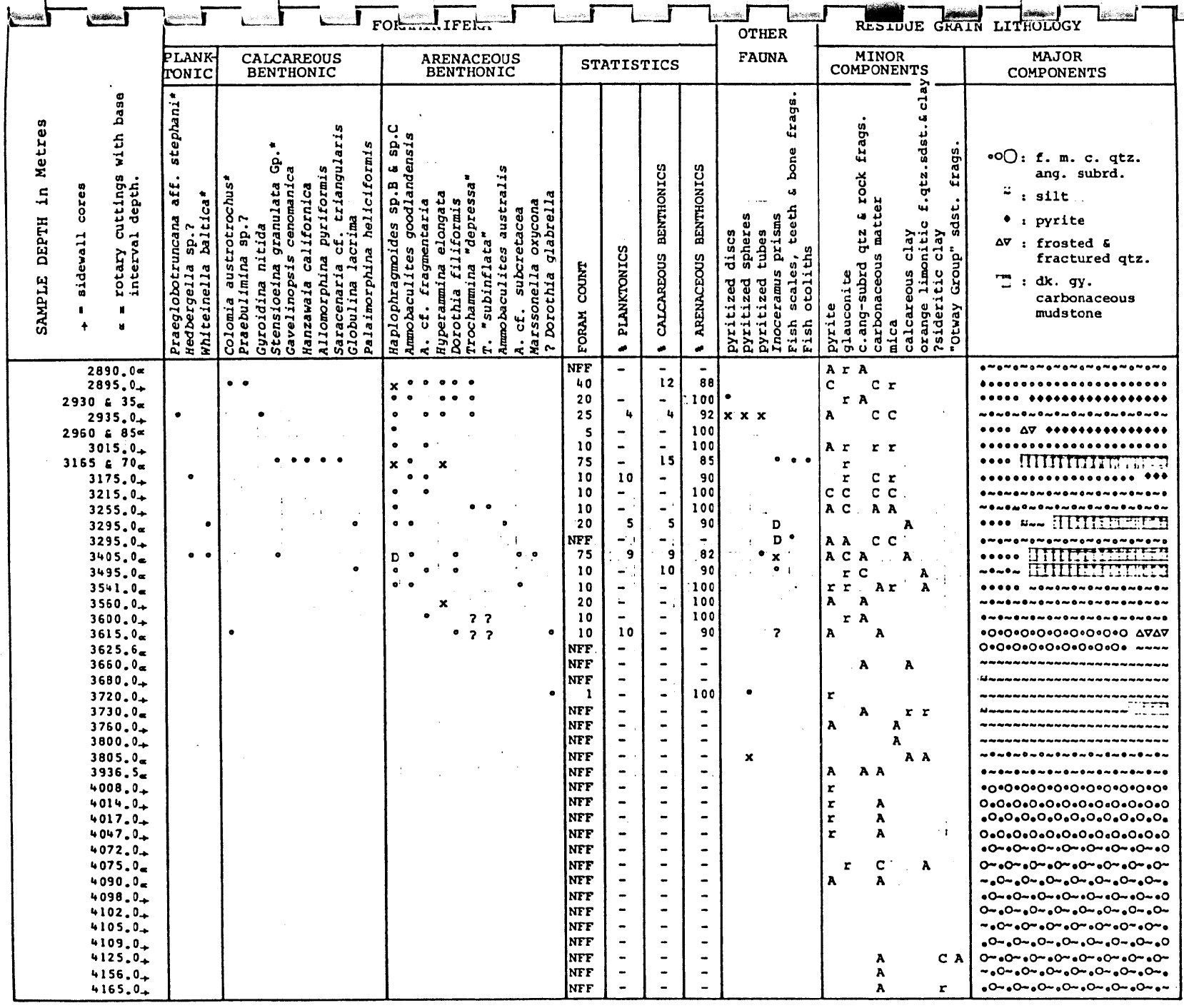

FIGURE 5: MID CRETACEOUS FORAMINIFERAL DISTRIBUTION and SEDIMENT ANALYSIS - BRIDGEWATER BAY # 1: 2890m to 4165m.

*refer text and Figure 2. Refer Figure 3 for Distribution Symbols.

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