8. NEOGENE BENTHIC FORAMINIFERAL BIOFACIES OF THE NEW JERSEY TRANSECT

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ABSTRACT

Quantitative study of benthic foraminifers from the upper Miocene to lower Pliocene section at Site 612 (1404 m present water depth) and the Pliocene section at Site 613 (2323 m present water depth) shows no evidence of widespread downslope transport of shallow-water biofacies or reworking of older material in the greater than 150 µm size fraction. In contrast, upper Miocene sediments from Site 604 (2364 m present water depth) show extensive reworking and downslope transport. At Site 612, benthic foraminifers show a succession from an upper Miocene Bulimina alata-Nonionella sp. biofacies, to an uppermost Miocene Bulimina alazanensis biofacies, to a lower Pliocene Cassidulina reflexa biofacies, to an upper Pliocene Melonis barleeanum-Islandiella laevigata biofacies. Evidence suggests that the Pliocene biofacies are in situ, although they could have been transported downslope from the upper-middle bathyal zone. At Site 613, Uvigerina peregrina dominated the “middle” Pliocene, while Globocassidulina subglobosa was dominant in the early and late Pliocene. High abundances of U. peregrina at Site 613 are associated with high values of sedimentary organic carbon.

INTRODUCTION

On DSDP Leg 95, we drilled two sites on the passive U.S. continental margin off New Jersey: the lower continental slope Site 612 (1404 m present water depth; 38°49.21'N, 72°46.43'W) and the upper continental rise Site 613 (2323 m present water depth; 38°46.26'N, 72°30.43'W). These sites, together with Sites 604 and 605 on the upper rise (van Hinte, Wise et al., in press), recovered thick Eocene and upper Miocene–Holocene sections. These sections are punctuated by numerous unconformities as a result of downslope erosion (Miller et al., 1985; Poag, 1985; Poag and Mountain, this volume; Poag and Low, this volume).

The Neogene record of benthic biofacies distribution on the New Jersey slope and upper rise is poorly known because of lack of material recovered prior to Legs 93 and 95. Paleoenvironmental interpretations of continental slope and rise biofacies may be complicated by downslope movement of shallow- and deep-water components. Despite the importance of downslope processes in continental margin erosion and transport (e.g., Natland, 1963; Stanley and Unrug, 1972; May et al., 1983), Holocene continental slope to upper rise benthic foraminifers (>150 µm size fraction) from the northeastern U.S. margin show regionally consistent biofacies distribution with little evidence for downslope contamination (Miller and Lohmann, 1982; Streeter and Lavery, 1982). These authors noted that a Recent Uvigerina peregrina biofacies dominates the margin between about 900 and 2500 m, associated with carbon and silt maxima in the slope and upper rise sediments. During the glacial Pleistocene, this U. peregrina biofacies became established in abyssal depths (>3000 m) in the North Atlantic (Streeter and Shackleton, 1979; Ledbetter and Balsam, 1985), indicating a dramatic difference in the abyssal benthic environment between glacial and interglacial periods.

We have found little evidence for displaced benthic foraminifers both in the Holocene (Miller and Lohmann, 1982) and in the Eocene (Miller and Katz, this volume) on the margin off New Jersey. Eocene faunal patterns at Sites 612 and 613 are consistent with those observed at other deep-water DSDP sites. In contrast, the Pleistocene sections at Sites 612 and 613 show evidence of reworking of older material and downslope contamination by shallower material (Site 612 and 613 chapters; Poag and Low, this volume; Scott, this volume) and possible downslope transport of a Pleistocene Elphidium-dominated fauna (Site 612 and 613 chapters; Scott, this volume). We quantitatively examined benthic foraminifers from the upper Miocene to Pliocene sections at Sites 612 and 613 in order to evaluate distributional trends and to determine the extent of reworking and displacement of faunas. Pleistocene benthic foraminifers from these sites are discussed by Scott (this volume) and Poag and Low (this volume). Neogene biostratigraphic control is coarse at Sites 612 and 613 as a result of the scarcity of marker taxa (Site 612 and 613 chapters). Despite complications due to limited stratigraphic control and some reworking, we document general biofacies distributions during the late Miocene to Pliocene.

METHODS

Benthic foraminifers were studied quantitatively from samples taken from the upper Miocene–Pliocene sections recovered at Site 612 (12 samples; Table 1) and the Pliocene section at Site 613 (6 samples; Table 2). Additional core catcher samples were examined qualitatively for stratigraphic ranges. Twelve additional samples from Site 613 were examined quantitatively for Uvigerina abundances (Table 3). Six samples (supplied by S. W. Wise) from the upper Miocene section at Site 604 (2364 m present water depth) were qualitatively examined for evi-
dence of reworking and downslope contamination. Samples from the upper Mississippian of Site 613 contained insufficient foraminifers for quantitative study.

The samples were soaked in a hydrogen peroxide (3%) solution and washed through a 63-µm sieve with a sodium hexametaphosphate solution. Alliquots from the >150-µm size fraction were picked and mounted on a reference slide. Three hundred specimens were picked when possible. The census data are presented as percentages of the total benthic foraminifers counted (Tables 1, 2).

The use of the >150-µm size fraction for quantitative deep-sea benthic foraminiferal study is arbitrary. Scott (this volume) and Poag and Low (this volume) examined the >63-µm size fraction for benthic foraminifers; Lohmann (1978) and Miller and Lohmann (1982) examined the >250-µm size fraction, while Pfleger et al. (1953), Streeter (1973), and Streeter and Lavery (1982) examined the >150-µm size fraction. Schnitker (1974, 1979) used the >125-µm size fraction. We routinely use the >150-µm size fraction because this avoids problems involved in identifying small specimens and it is faster to pick. Although the abundances of some very small taxa are underestimated (e.g., Epistominella spp., cf. Streeter, 1973 and Schnitker, 1974; Bolivina spp., cf. Miller et al., 1984, and Poag et al., 1984), many faunal patterns are observable in coarser size fractions. For example, the widespread dominance of *Uvigerina peregrina* in slope sediments has been observed in the >250-µm fraction (Miller and Lohmann, 1982), the >150-µm fraction (Streeter and Lavery, 1982), the >125-µm fraction (Schnitker, 1979), and the >63-µm fraction (Scott, this volume).
Table 2. Benthic foraminiferal census data, Site 613.

<table>
<thead>
<tr>
<th>Core-Section</th>
<th>Sub-bottom depth (m)</th>
<th>Number counted</th>
<th>Uvigerina spp. (%)</th>
<th>U. peregrina (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core-Section</td>
<td>13,CC</td>
<td>315</td>
<td>0.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Core-Section</td>
<td>14,CC</td>
<td>21.6</td>
<td>237</td>
<td>34.2</td>
</tr>
<tr>
<td>Core-Section</td>
<td>15,CC</td>
<td>221.3</td>
<td>320</td>
<td>56.9</td>
</tr>
<tr>
<td>Core-Section</td>
<td>16,CC</td>
<td>226.6</td>
<td>514</td>
<td>79.2</td>
</tr>
<tr>
<td>Core-Section</td>
<td>17,CC</td>
<td>226.6</td>
<td>126</td>
<td>60.3</td>
</tr>
<tr>
<td>Core-Section</td>
<td>18,CC</td>
<td>244.3</td>
<td>177</td>
<td>10.2</td>
</tr>
<tr>
<td>Core-Section</td>
<td>19,CC</td>
<td>258.5</td>
<td>268</td>
<td>48.8</td>
</tr>
</tbody>
</table>

Table 3. Neogene relative abundances of Uvigerina spp., Site 613.

<table>
<thead>
<tr>
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<td>19,CC</td>
<td>258.5</td>
<td>268</td>
<td>48.8</td>
</tr>
</tbody>
</table>

RESULTS

The Pliocene/Pleistocene boundary has been placed within Core 5 at Site 612 (Site 612 chapter; Poag and Low, this volume). However, Scott (this volume) placed the boundary below Core 5 at Site 612 on the basis of the presence of the benthic foraminiferal species Elphidium excavatum and Fursenkoina fusiformis, which he interpreted as in situ Pleistocene taxa. Based upon the presence of reworked Tertiary and Cretaceous microfossils and glauconite in his samples, Scott suggested that the shipboard placement of the boundary was erroneous. In contrast, we found only a few shallow-water specimens in Cores 7 and 8 and little evidence of reworked older material. Furthermore, Globorotalia tosaensis (zonal criterion base Zone N21, upper Pliocene) first appeared between Samples 612-7,CC and 612-8,CC, whereas the Pleistocene marker G. truncatulinoides first appeared between Samples 612-4,CC and 612-5,CC, consistent with the nonnannofossil biostratigraphy. We therefore agree with the site chapter and Poag and Low (this volume), and place the upper Pleistocene/upper Pliocene contact at the unconformity noted in Core 5, Section 3.

Benthic foraminiferal first and last occurrences are scattered throughout the studied section, with two exceptions (Fig. 1; Table 1):

1. Several last occurrences are found in Core 13 (Fig. 1). These last occurrences are associated with an unconformity that separates upper upper Miocene (Messinian) from lower upper Miocene (Tortonian) strata (Poag and Low, this volume).

2. The greatest number of disappearances (10) occurs in Core 11 just above the Miocene/Pliocene boundary (Fig. 1), which is recognized by the first occurrences of Ceratolithus acutus (Valentine, this volume) and Globorotalia cf. margaritae (Site 612 chapter) in Sample 612-11,CC. The boundary as drawn here (Core 11) is above where the first pinhole apertures were noted in Sphaeroidina in Sample 612-13,CC (Site 612 chapter).

With the exception of Buliminella elongata, all of the taxa that exhibit last occurrences in this section at Site 612 are known to range into the Holocene elsewhere. Poag (1984) reported that B. elongata last occurs in the upper Pliocene of the U.S. Atlantic continental shelf, although at Site 612 it last occurs in the Miocene.

There is an upsection progression of species dominance at Site 612. Bolivina alata and Nonionella sp. have highest relative abundances below the upper Miocene unconformity (Fig. 2). Buliminina alazanensis occurs in high abundance in the uppermost Miocene, and is virtually absent from other portions of the section. Cassidulina reflexa becomes dominant in the lower Pliocene, followed in the upper Pliocene by Melonis barkeanum and Islandiella laevigata.

With the exception of large lenticulinds (Lenticulina ?americana) noted in Sample 612-5,CC there is no significant faunal evidence for reworking of older material or contamination by shallow-water species in the >150-µm size fraction from the Neogene section at Site 612. Widespread contamination might be expected (see Dis-
Figure 1. Range chart of Miocene-Pliocene benthic foraminifers at Site 612. Tick marks indicate levels examined for benthic foraminifers. Dashed lines mean uncertain range; x = isolated occurrence.

Figure 2. Abundances (%) of dominant taxa at Site 612.

cussion) considering that the Neogene section is a channel-fill deposit (Poag and Mountain, this volume; G. Mountain, pers. comm., 1985) and visual evidence indicates allochthonous material in Core 13 (chert pebbles, shell fragments, a 3-cm bone fragment; Site 612 chapter). However, the only evidence for reworking and contamination at Site 612 in the >150-µm size fraction is (1) several reworked specimens in Sample 612-7,CC (upper Pliocene, Lenticulina sp. and Globob bulimina sp.); (2) a solitary specimen of shallow-water Hanzawaia cf. concentrica in Sample 612-8,CC (upper Pliocene); and (3) a solitary specimen of a shallow-water Eponides sp. in Sample 612-14-2, 60-64 cm (lower upper Miocene).

Site 613

The Miocene/Pliocene boundary has been placed within Core 19 at Site 613 (Site 613 chapter). There is evidence for limited faunal reworking and downslope contamination in Cores 17, 18, and 19 (Miocene—lower Pliocene). Sample 613-19,CC (upper Miocene) contains one
specimen of *Hanzawaia ammophila*, a common form in the Eocene of Sites 612 and 613 (Miller and Katz, this volume) which ranges into the early Miocene elsewhere. This specimen is either reworked or a laboratory contaminant. Reworked Eocene nannofossils were reported from Sample 613-19,CC (Site 613 chapter), although no Eocene planktonic foraminifers were found. Otherwise, there is no evidence for contamination of this sample. Benthic foraminifers are sparse in Sample 613-19,CC, but apparently represent an in situ late Neogene fauna (*Uvigerina hispida*, *Bulimina alazanensis*). Section 613-19-3 (upper Miocene) contains a very sparse fauna consisting of predominantly reworked specimens including Eocene-Oligocene planktonic foraminifers (*Subbotina linaperta* and *S. cf. S. sellii*). Most benthic taxa in Sample 613-18,CC (lower Pliocene) are interpreted as in situ, although a few shallow-water specimens were noted, including *Buccella* sp., *Hanzawaia cf. H. concentrica*, and *Eponides* sp. Reworked Eocene radiolarians were also identified in this sample (Site 613 chapter). Sections 613-13-5 to 613-13-1 (upper Pliocene) contained some reworked Eocene radiolarians (*Site 613 chapter*). The remainder of the Pliocene section at Site 613 showed no evidence of reworking or contamination in the >150-μm size fraction. The Pliocene/Pleistocene boundary has been placed within Core 11 (Site 613 chapter). Samples from Core 12 contain very sparse faunas and are not included in this study.

Nearly all of the taxa that show last occurrences in the Pliocene section at Site 613 are known to range into the Recent (Fig. 3). The only first occurrence that appears to be stratigraphically significant is *Islandiella laevegata* in Zone PL2. *Islandiella laevegata* first appeared in Site 612 in Zone N21. Continuously ranging taxa and infrequently occurring taxa are listed in Table 2 and in the Appendix.

Quantitative studies (Fig. 4) show that *Globocassidulina subglobosa* dominates the benthic fauna in the lower Pliocene at Site 613. This biofacies is replaced in the “middle” Pliocene by a *Uvigerina* biofacies, including *U. peregrina* and *U. hispida*. There is a suggestion in our uppermost sample that *G. subglobosa* regains species dominance in the upper Pliocene.

**Sites 612 and 613 Compared with Site 604**

Examination of six samples from lower upper Miocene (Zones CN7-CN8 = NN9-NN10) at Hole 604 (Wise et al., in press) shows considerable evidence of downslope transport of Miocene and reworking of Eocene foraminifers. This is not surprising, considering the fact that the sediments examined consist of debris flow deposits in the thalweg of a buried channel system. In contrast, Site 613 was drilled in an interchannel area and slightly upslope from Site 604, where the upper Miocene section is considerably thinner and shows much less benthic foraminiferal evidence for transport and reworking.

Sample 604-30-1, 38-40 cm consists of an Eocene clast in a upper Miocene matrix (Zone CN7 = NN9; Wise et al., in press). Foraminifers indicate that this clast is of middle Eocene age, containing a benthic and planktonic fauna similar to that found at nearby Site 613 (*Truncorotaloides rohri*, *Acarinina bullbrooki*, *A. pentacamera*).
ta, A. aragonensis, Bulimina trinitatensis, Cibicidoides subspiratus, and C. tuxpamensis), suggesting that the slump blocks were not transported a great distance downslope.

Samples from Cores 604-26 and 27 contain a middle to late Miocene planktonic foraminiferal fauna with reworked Eocene foraminifers: (1) Samples 604-27-1, 102-104 cm and 604-27-1, 114-115 cm, Eocene: Truncorotaloides rohri, Catapaxidrax unicus; Miocene: Globigerinoides sacculifer; (2) Sample 604-27-1, 23-25 cm, Eocene: Acarinina sp.; Miocene: Globigerinoides trilobus, Globobulimina dehiscens; Sample 604-26-3, 52-54 cm, Eocene: T. rohri; Miocene: Neogloboquadrina contin-osa, Globorotalia menardii, Orbulina sp.

In addition to reworking of Eocene foraminifers, there is evidence of significant downslope transport at Site 604. The benthic fauna of Sample 604-26-3, 52-54 cm contains abundant diverse shallow-water neritic elements (Cibicides spp. and Hanzawaia cf. H. concentrica), and a fauna which may be of deeper water origin (including Sphaeroidina bulloides, Cibicidoides pachycerma, and Melonis barleeanum). Sample 604-27-1, 23-25 cm contains a fauna similar to that described from the Miocene of upslope Site 612: Cassidulina reflexa, Bolivina alata, Bulimina alazanensis, and Nonionellina sp. It is possible that the fauna was transported from the vicinity of Site 612 to Hole 604; however, lack of comparative Miocene material at Site 613 prevents determination of the nature of in situ fauna in the vicinity of Hole 604.

These mixtures of in situ, reworked, and transported fauna from the upper Miocene at Site 604 contrast with the primarily in situ record from the Pliocene of Site 613 and the Miocene–Pliocene of Site 612. The difference in transported material among the three sites can best be explained by their geologic settings. Hole 604 lies in the channel thalweg, penetrates basal Tortonian strata, and contains clasts, reworked foraminifers, and downslope contaminants. Site 613 is located on the nearby interchannel area, penetrated only a thin Messinian section, and has little evidence of reworking or contamination. Site 612 is located updip slightly off of the thalweg of a basal Tortonian canyon and contains little evidence of reworking or contamination.

**DISCUSSION**

Benthic foraminifers identified in the Miocene–Pliocene sections of Sites 612 and 613 are distinct from coeval biofacies of the U.S. Atlantic emergent coastal plain (Miocene Pungo River and Pliocene Yorktown Formations; Gibson, 1967; Schnitker, 1970) or submergent coastal plain (continental shelf ASP, AMCOR, COST boreholes; Poag, 1984; Melillo, 1985). Typical Neogene coastal plain biofacies consist of neritic taxa including: Bolivina paula, Buliminella elongata, Buliminella elegantissima, Cassidulina crassa, Islandiella laevigata, Elphidium sp., Epistominella pontoni, Floritus pizzarenensis, Hanzawaia concentrica, Nonionella sp., and Trifarina angulosa (Gibson, 1967; Poag, 1984). This biofacies also has been noted from upper Oligocene strata in this region (Olsson et al., 1980) and in southwest France (Butt, 1966). A shallower, lower diversity inner neritic biofacies has been reported from upper levels of the Yorktown Formation consisting of dominant Elphidium sp., Buccella sp., Rosalina sp., and Nonionella sp. (Gibson, 1967; Schnitker, 1970). In contrast, the benthic foraminiferal assemblages at Sites 612 and 613 contain mostly known middle bathyal–abyssal taxa: Anomalinaoides globulosus, Bulimina aculeata, B. alazanensis, Cibicidoides bradyi, C. mundus (= kulkenbergi), Eggerella bradyi, Ehrenbergina sp., Globobulimina sp., Globocassidulina subglo-boa, Hoeglundina elegans, Melonis barleeanum, Ord-orsalis sp., Planulina wuellerstorfi, Pullenia quinque-loba, P. bulloides, Sigmoliopsis schlumbergeri, Karrieraella subglobra (= bradyi), Sphaeroidina bulloides, Uvigerina peregrina s.s., and Uvigerina hispida (see van Morkhoven et al. [in press] for discussion of the bathymetric ranges of these taxa).

It is not clear whether the Neogene foraminifers at Sites 612 and 613 represent entirely in situ biofacies (Site 612 and 613 chapters). The Neogene section at Site 612 was deposited in a canyon cut near the end of the middle Miocene; the Neogene section at Site 613 was depos-
ited as a basal slope fill on an interchannel area of the continental rise (Poag and Mountain, this volume). Some downslope movement of benthic foraminifers was anticipated because of this geological setting. Scott (this volume) acknowledged that the Pleistocene Elphidium–Cassidulina reniforme fauna at Sites 612 and 613 may be a transported glacial ice-margin fauna. However, he favored an in situ interpretation for these faunas based upon the presence of living (stained) Elphidium sp. on the modern slope (Schafer et al., 1981). We note rare shallow-water elements (Buccella, Discorbis, Eponides) and reworked Eocene taxa in the Miocene–Pliocene sections at Sites 612 and 613 (see above, Tables 1, 2). However, we believe that the major faunal elements are in situ. At Site 613, the Pliocene Uvigerina–Globocassidulinina biofacies are consistent with the present lowermost bathyal–uppermost abyssal setting. At Site 612 it is possible that Cassidulina reflexa, Islandiella laevigata, Nonionellina sp., and Bolivina alata represent shallower (upper–middle bathyal) elements transported downslope to this lower bathyal setting. However, we believe that the consistent distributional patterns of these taxa (Fig. 2) argue against extensive downslope transport. Nevertheless, (1) if transported elements episodically filled the Neogene channel, they may have been missed by our limited sampling interval, (2) transported elements may be spatially restricted to the same biofacies (hence undetectable), or (3) transported elements may be confined to the finer than 150-μm size fraction (however, Poag and Low [this volume] found little evidence of shallow-water forms in the >63-μm fractions that they examined).

Uvigerina peregrina dominates the >150-μm size fraction of modern continental slope and rise biofacies off New Jersey between about 1000 and 2500 m (Miller and Lohmann, 1982; Streeter and Laverly, 1982). Lutze (1980) and Miller and Lohmann (1982) noted that U. peregrina correlates with high sedimentary organic content; Miller and Lohmann suggested that Uvigerina peregrina was favored in regions of high organic carbon because of reduced interstitial oxygen and/or lowered oxygen values in overlying water. During the last glacial maximum this taxon was dominant on the lower rise (>3000 m; Ledbetter and Balsam, 1985; Balsam, 1981) and in the deep basin (Streeter and Shackleton, 1979). Prior to Leg 95, it was not clear if Uvigerina was important on the slope and upper rise before the Holocene. Scott (this volume) found that U. peregrina was important at Site 612 only in the Recent and in Cores 5–8 (Section 612-5 is upper Pleistocene, Site 612 chapter; we argue that Section 612-5 to Core 612-8 are upper Pleistocene; see above).

We note that Uvigerina peregrina occurred in low abundances (<2%) on the slope at Site 612 during the Miocene–Pliocene. This taxon dominated the upper rise biofacies at Site 613 during the “middle” Pliocene, but occurred in low abundances during the rest of the Pliocene (Fig. 4). We used the Pliocene section at Site 613 to test the association of high abundance of Uvigerina with high sedimentary organic carbon. Weight percent organic carbon (Table 4) for Pliocene samples from Site 613 was analyzed on a LECO Carbon Analyzer at Woods Hole Oceanographic Institution (data provided by W. B. Curry). Comparison of the distribution of Uvigerina with percent organic carbon (Fig. 4) shows that high values of Uvigerina (>30%) are associated with high organic carbon values (>1%). Highest values of Uvigerina (60–80%) are associated with highest (1.2–1.4%) organic carbon values and a homogenous, clay-rich zone (Cores 14–16) identified by visual observation and on gamma logs (Site 613 chapter). We suggest that the “middle” Pliocene acme of Uvigerina spp. at Site 613 represents an interval of increased supply of organic carbon, which reduced the oxygen content of interstitial and possibly overlying water.

ACKNOWLEDGMENTS

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REFERENCES


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**APPENDIX**

**Neogene Benthic Species List**

**Inferred In Situ Taxa**

*Anomalinoidea globulosus* (Chapman and Parr)

*Bolivina alata* (Seguenza)

*Bulimina aculeata* (d'Orbigny)

*B. alizonensis* Cushman

*B. giba* Foraminifera

*B. marginita* (d'Orbigny)

*B. striata mexicana* Cushman

*Bulimina elongata* (d'Orbigny)

*Cassidulina crassa* (d'Orbigny)

*C. reflexa* Galloway and Wissler

*Cibicides lobatus* (Walker and Jacob)

*Cibicides brevi* (Trauth)

*C. incrassatus* (Fichet and Moll)

*C. mundulus* (Brady, Parker and Jones)

*C. pachyderma* (Rzehak)

*Euggerella brevi* (Cushman)

*Fusulina japonica* (Cushman)

*Globobaculina subglobosa* (Brady)

*Hoejlandina elegans* (d'Orbigny)

*Islandiella laevigata* (d'Orbigny)

*Karreriella subgloba* (Guembel)

*Melonis barleeanum* (Williamson)

*Orispira umbonatus* (Reuss)

*Plaminina rugosa* (Phleger and Parker)

*P. westlerstorfi* (Schwager)

*Praegobuliminula spinescens* (Brady)

*Pullenia bulloides* (d'Orbigny)

*P. quinqueloba* (Reuss)

*Signicolipis schlumbergeri* (Silvestri)

*Sphaeroidina bulloides* (d'Orbigny)

*Sitostomella aculeata* (Cushman and Renz)

*S. curvaturea* (Cushman)

*S. lepidula* (Schrader)

*Uvigerina gallowayi* Cushman

*U. higida* Schrader

*U. mediterranea* Hooper

*U. peregrina* (Cushman)

*U. proboscidea* Schrader

*Vulvarina laevigata* Phleger and Parker

*Vulvarina spinosa* Cushman

**Shallow-Water Taxa Noted in the Miocene-Pliocene at Sites 612 and 613**

*Lenticulina cf. americana* (Cushman)

*Hanzawaia concentrica* (Cushman)

*Reworked Eocene Benthic Taxa Noted in the Miocene at Site 604*  

*B. trinitatensis* (Cushman and Jarvis)

*C. subspissiformis* (Cushman and Stainforth)

*T. frigida* (d'Orbigny)

*T. lenticula* (d'Orbigny)

*U. hispida* (Cushman)

*V. laevigata* (Cushman)

*V. spinosa* Cushman

*W. wuellerstorfi* (Reuss)
Plate 1. Scale bar = 100 µm. 1A-B. *Bolivina alata*. Sample 612-14-2, 60-64 cm. 2A-B. *Bulimina aculeata*. Sample 612-7-2, 60-64 cm. 3A-B. *Fursenkoina mexicana*. Sample 612-8, CC. 4. *Buliminella elongata*. Sample 612-14-2, 60-64 cm. 5A-B. *Bulimina marginata*. Sample 612-11, CC. 6A-B. *Bulimina striata mexicana*. Sample 612-11-2, 60-64 cm. 7A-B. *Bulimina alazanensis*. Sample 612-12-5, 7-9 cm.
Plate 4. Scale bar = 100 µm. 1A-C. Nonionella sp. Sample 612-13, CC. 2A-B. Sigmoilopsis schlumbergeri. Sample 612-14, CC. 3A-C. Nonionellina sp. Sample 612-14, CC. 4A-B. Karreriella subglabra. Sample 612-14, CC. 5A-B. Melonis sphaeroides. Sample 612-14-2, 60-64 cm. 6A-B. Melonis barleeanum. Sample 612-7-2, 60-64 cm. 7A-B. Astronion sp. Sample 612-13, CC.
Plate 5. Scale bar = 100 µm. 1A-C. *C. pachyderma*. Sample 612-11,CC. 2A-C. *Cibicidoides mundulus*. Sample 612-13,CC. 3A-C. *C. bradyi*. Sample 612-11,CC. 4A-C. *Planulina wuellerstorfi*. Sample 612-11-2, 60-64 cm.